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A MANAGERIAL APPROACH TO NASA'S CULTURAL CHANGES: OPEN SYSTEM MODEL

by

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13. ABSTRACT

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To conduct this research, books, online resources, newspaper article, technical and investigative reports and theses provided the main sources of information.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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I. INTRODUCTION

A. PURPOSE

This research examined the interaction of external and internal organizational variables affecting cultural changes occurring in NASA (National Aeronautic Space Administration) during different time-periods. To the extent that organizational cultural behaviors played some substantial part in the unfortunate Challenger (1986) and Columbia (2003) shuttle disasters, then exploring cultural relationships and impacts is a worthwhile endeavor. The objective is to learn more about how enduring differences in organizational values and other interacting variables can generate powerful organizational cultures and sub-cultures, thereby impacting performance. This study also supports, upholds and augments the very goal of the shuttles missions which was to learn about humans exploring space.

Two timeframes were selected and evaluated to describe and analyze aspects of NASA's structural, political and cultural history. In the first timeframe, 1958–1972, cultural characteristics are described which may have positively contributed to the successful landing and return of a man on the moon. During the second timeframe, 1996–2004, culturally relevant factors are described and analyzed in terms of possible negative impacts to the Columbia shuttle disaster. These two timeframes represent fundamental yet different configurations of NASA's history viewed from the perspective of organizational culture and performance.

The goal of the project was to identify, describe, and analyze variables contributing to NASA's dominant and alternative cultures during the two different time periods. Organizational culture is defined here as: a pattern of basic assumptions, invented, discovered, or developed by a given group, as it learns to cope with its problems of external adaptation and internal integration that has

worked well enough to be considered valid and, therefore, is to be taught to new members as the correct way to perceive, think, and feel in relation to those problems. (Schein, 1990, p. 111)

Open systems theory provides a useful theoretical foundation for the study, including using the McCaskey model (1974) as the primary diagnostic instrument. For reasons explained later, the model is modified by placing culture at the center and referring to other components as explanatory variables, e.g., context, structure, task, people, and resources. A *system* is any set of interacting components working together towards some common purpose (Senge, 2006). Theoretically, the extent to which key variables are aligned or congruent determines organizational performance. This concept reflects both the central hypothesis of systems thinking and the construct used to relate variables interrelationships to each other. A fit among the patterns of relevant contextual, structural and strategic factors will yield better performance than misfits will (Doty, 1993). Donaldson concurs in that, “misfit produces negative effects on organizational performance” (1987, p. 15). Organizational leaders striving to develop the kind of cultures which produce superlative performance would therefore need to understand the central role culture can play in affecting organizational outcomes, including intended and unintended consequences.

B. BACKGROUND

After the Second World War, the Cold War between the United States and the Soviet Union emerged and continued for over four decades. The Cold War was generally recognized as a fundamental struggle between democracy/capitalism and communism. The space race took on both a symbolic and military meaning for most Americans. When the Soviet Union succeeded in launching Sputnik, United States citizens and people’s from other nations perceived that the United States might be losing the space race, and communism was winning (Launius, 1995). The societal and political pressures were on to

catch up to and overtake the Soviet Union in the space race. This context contributed to the establishment of the National Aeronautics and Space Administration (NASA) (Launius, 1995; McCurdy, 1993).

NASA was established in 1958 to explore space and to better understand our own planet and the universe around us. In 1961, President John F. Kennedy inspired the nation and created a powerful and compelling vision about sending a man to the moon and returning him safely before the end of the decade.

From establishment to the mid 1970s, NASA received substantial financial and management support from the President, Congress, and the American people. During this period, NASA landed the first man on the moon, developed preeminent technological skills, and became the pride of the nation and parts of the world. After this tremendous accomplishment and into the 1970s, the United States became preoccupied with the Vietnam War (Launius, 1995; McCurdy, 1993). Consequently, societal harmony and overall economic conditions deteriorated, including imminent governmental budget cuts for the years ahead.

NASA was a successful, entrepreneurial and maturing organization and management developed diverse goals to survive and stimulate growth. Among these goals were implementing space explorations to solve problems on Earth, reducing space exploration costs, and routinely accessing space with shuttles.

As contextual and internal organizational design factors continued to change into the 1980s, NASA experienced some failures, e.g., the Challenger disaster in 1986 which exploded during takeoff killing all seven astronauts. President Reagan ordered the Rogers Commission to investigate the accident which found – among other things – that shuttle design flaws contributed heavily to the Challenger's explosion. Basically, the Space Shuttle Challenger disintegrated when an O-ring seal in a solid rocket booster (SRB) failed at liftoff. The ruptured seal and failed backup seal allowed a breach in the SRB joint, which allowed escaped gases to combust upon reaching the outside attachment hardware and external fuel tank. The SRB breach flare caused

both the separation of the right-hand SRB and the structural failure of the external tank. Aerodynamic forces broke up the shuttle in 73 seconds after liftoff with all seven souls on board killed.[1]

During the Challenger investigation, the Rogers Commission found that some senior managers and NASA engineers knew the design problem existed and failed to act appropriately on contested, but available information. Although data about the problem was discussed the day before takeoff, why did NASA decision makers fail to prevent the launch? One stunning explanation for this failure to take appropriate action was that NASA's cultural conflicts may have prevented or clouded rational decision-making by losing sight of crucial safety parameters, including a gap between engineering and managerial cultures. Sapienza (1987) asserts that culture can affect the mechanisms whereby decision makers perceive and interpret data, i.e., shaping the importance that managers attach to incoming information.

Seventeen years later on February 1, 2003, the Columbia space shuttle disintegrated when entering the atmosphere after a 16-day science mission and all seven astronauts died. The Columbia Accident Investigation Board (CAIB) was established and reported its findings. Interestingly, although the foam problem that caused the accident was known by both senior managers and engineers soon after takeoff, ineffective decision-making once more loomed, i.e., the CAIB highly criticized the management and culture of NASA.

Both accidents show that cultural analysis of NASA is reasonable and necessary to search for causation factors and preventive actions. Since organizational culture includes deeply ingrained behaviors, language, and repeated patterns, which are often difficult and slow to change, this analysis includes relevant contextual factors and organizational components likely affecting culture.

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[1] See for more technical information at Houston Chronicle, Chron.com, http://www.chron.com/content/interactive/special/challenger/docs/report.html, (accessed October 2007).

Clearly, NASA has existed for many years and its culture has evolved with the development of the agency over time. Meek (1988, p. 464) stated, “People do not just passively absorb meanings and symbols; they produce and reproduce culture and in the process of reproducing it, they may transform it.” Cultural transformation can take a long time to occur and is decidedly complex which appears to be a good fit for a longitudinal approach.

The study is pseudo-longitudinal in that it compares NASA’s Columbia (1996–2004) and man-on-the moon periods (1958–1972). The Columbia period is particularly important both because it is closer to the present time, and because it may delineate a marked contrast from NASA’s earlier successful moon accomplishments.

C. RESEARCH QUESTIONS

1. Primary Questions

- To what extent did aspects of NASA’s culture support (degrade) its mission and tasking during the “man-on-the-moon” period (1958–1972) and during the space shuttle period prior to the Columbia disaster (1996–2004)?
- To what extent did identifiable variables contribute to developing an incongruent NASA culture, and what can decision makers learn about intervening and changing variables under their control for greater alignment of internal and external factors, thereby positively affecting culture and organizational performance?

2. Secondary Questions

- How can NASA’s culture between 1958–1972 and 1996–2004 be described?
- What appear to be the primary contributing factors (driving forces) to NASA’s culture during those two periods?
- To what extent were NASA’s cultural variables congruent or incongruent with relevant tasks during 1958–1972?
- To what extent were NASA’s cultural variables congruent or incongruent with relevant tasks during 1996–2004?

D. METHODOLOGY

This project adopted an open-systems theory framework, particularly in terms of describing an organizational system using a model developed by McCaskey (1974). The model was changed slightly by placing culture at the center of the model, opposed to viewing culture as a result of the interaction among external environmental variables and internal organizational design factors.

E. ORGANIZATION OF STUDY

Chapter I introduces the topic, and chapter II examines literature on the relative importance of organizational culture, including a brief historical depiction of cultural domains, i.e., how culture may affect organizational functions and processes. Chapter III reviews McCaskey's organizational systems model and open-system theory and relates them to the cultural concept. Chapter IV describes NASA's early cultural formation and other relevant characteristics during the "man-on–the-moon" period (1958–1972) and analyzes overall fit with the task, people, structure, and resources. In Chapter V, the characteristics of NASA's culture during the Columbia period (1996–2004) are analyzed including fit with task, people, structure, and resources. Finally, chapter VI summarizes the findings and incorporates them into recommendations for assisting managers in diagnosing and positively influencing their organizational cultures.

F. LIMITATIONS

We have tried to show the alignment of NASA's organizational components and its culture within academic and course time constraints. All deductions are based on documents and literature sources due to an inability to interview NASA personnel. As stated, two fairly distinct periods of NASA's history only are analyzed: the-man-on-the moon period (1958–1972) and the Columbia period (1996–2004), e.g., the time period between 1972 and 1996 is not included in the study.

There are numerous environmental forces that could have affected NASA's management and culture. This project focused on the President, Congress, and the space environment as primary environmental variables affecting the agency's culture. Other environmental forces such as the effect of societal and media factors are briefly referenced.

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II. CULTURE

A. DEFINITIONS

People deal with culture on a daily basis in their jobs, schools, and social groups, perhaps without recognizing its potential impacts on societal values and organizational performance. Various professional groups—sociologists, psychologists and anthropologists—have studied culture, often concluding that both societal culture and organizational culture can run deep in terms of entrenched behaviors and accepted patterns. A premise of this study is that managers and leaders are well advised to seek greater understanding of how culture evolves over time, particularly the challenge of positively influencing organizational culture. Various definitions, roles and references to culture appear frequently in contemporary social science academic and practitioner literature.

The American Heritage Dictionary (2007) defines culture in the following two general ways:

Culture is "the totality of socially transmitted behavior patterns, arts, beliefs, institutions, and all other products of human work and thought; and these patterns, traits, and products considered as the expression of a particular period, class, community, or population;" and/or culture is "the predominating attitudes and behavior that characterize the functioning of a group or organization."

In the first definition, culture refers to human beings in the broad, societal context as the product of human socialization. In this aspect, we can argue that understanding culture is equal to understanding human beings within defined social settings. In the second definition, the scope and context of culture narrows. Two or more persons working toward an objective can develop a culture unique to their group. Isaac and Pitt (2001) add that "culture is an extremely subtle phenomenon" (Keyton, 2004, p.28).

The term *culture* appears to originate from social anthropology[2] (Kotter, 1992, p. 3). The first known publication to have culture in its title is the study of Edward B. Taylor's "Primitive Culture" in 1877. In his study, Taylor acknowledged that primitive societies, such as Eskimo and Native American, have different ways of life from other nations, but also different ways of life among themselves (Kotter, 1992).

In the organizational psychology field, Kaufman (1960) was an early researcher who analyzed the cultural characteristics of the U.S. Forest Service (McCurdy, 1993). He showed that forest rangers have a common culture although their organization is big in size with dispersed subunits, complex jobs and wide areas of responsibility. Kaufman observations were that "voluntary conformity" reinforced by the culture of the organization among rangers was a more powerful force than budgets, procedure manuals, and other financial mechanisms in ensuring the predictability in the activities of field employees (McCurdy, 1993, p. 5).

In all likelihood, culture existed as people developed social life in the form of clans, groups, and communities. However, theoretical and empirical studies about business organizational culture gained popularity in the 1980s with the increase of globalization[3]. Managers and researchers started to become more aware of different cultures because of increasing business interactions with people from other nations and organizations. This opportunity led to increased efforts to understand cultural differences in order to handle cultural-related issues in business settings. Competition varies under the globalization concept, but many point to Japanese firms showing periods of exceptional performance in the U.S., e.g., the automotive industry from the 1970s to the present. A broad tendency to explain the success of Japanese firms with their distinctive cultures

[2] Social anthropology is defined as "the branch of anthropology that deals with human culture and society," http://wordnet.princeton.edu/perl/webwn, (accessed August 21, 2007.

[3] According to Waters (1995, p. 3), globalization refers to "a social process in which the constraints of geography on social and cultural arrangements recede and in which people become increasingly aware that they are receding."

emerged among researchers and business practitioners. Japanese societal values of collectivism (over individualism), and orientation towards harmony with man and nature may form the foundations of business practices such as life time employment and the central importance of team work. This interest in exploring differences in culture may have been stimulated by the reality or perception that the U.S. was losing its national competitive edge on the world scene (Schein, 1996).

Early cultural studies may have lacked a systematic approach analyzing all relevant cultural dimensions (Schein, 1990). According to Mackenzie, it is very difficult to come up with an accepted theory for explaining organizational culture since organizations are constantly evolving (Marcoulides and Heck, 1993, p. 210). However, Mackenzie indicated that organizational culture is a helpful tool to use when assessing the relative fit of an organization's goals, strategies, tasks, and resulting outcomes.

Since there appears to be a plethora of organizational culture definitions, several further descriptions are provided. Uttal (1983) defined culture as a "system of shared values (what is important) and beliefs (how things work) that interact with a company's people, organizational structures, and control systems to produce behavioral norms" (p. 66). According to Williams, Dobson, and Walters (1989), organizational culture is "the basic pattern of shared assumptions, values, and beliefs considered to be the correct way of thinking about and acting on problems and opportunities facing the organization. It is a powerful template that shapes what happens in the organization" (McShane & Von Glinow, p. 253). Louis (1985) defined culture "as a set of understandings or meanings shared by a group of people. The meanings are largely tacit among the members, are clearly relevant to a particular group, and are distinctive to the group" (p. 74). Trice and Beyer (1993) noted, "organizational cultures, like other cultures, develop as a groups of people struggle to make sense of and cope with their world" (p. 4).

These different definitions suggest several important similarities about organizational culture. First, it consists of various levels of shared assumptions, values, and beliefs. Second, culture develops over time such that behaviors become normal, accepted and shared. Third, culture is transmitted and taught to new members in a process of socialization. Culture can guide organizational members' behavior by framing their interpretation of the internal and external environment. To understand better, how organizational culture characteristics develop, different levels of culture are discussed.

B. THE CONTENT OF CULTURE

When one enters a different group, organization, or even country, culture shock is a general term used to describe an overall perception of loneliness or inability to fit in with the local group. Notable differences can include alternative behaviors, physical structures, symbols and language. Even after staying long enough to become accustomed to a new environment, "outsiders" may still have difficulty understanding some behaviors. The initial cultural experience is often the tip of the iceberg—the artifacts of culture. Becoming familiar with cultural layers would tend to increase an individual's understanding of "the way things are done" in the new environment. The more the person knows about the culture, the more likely they are to understand why people behave the way they do.

Organizational culture can be described in terms of two fundamental levels compared to an iceberg: visible parts (observable behaviors and artifacts), and invisible parts (values, beliefs, and assumptions). Using a tree as the metaphor, the roots become the less visible parts of culture, and the branches and leaves are the observable aspects.

These broad cultural depictions are helpful yet insufficient for understanding the complex interrelationships of variables which may be involved in generating unique and varied cultures. Other scholars (Hofstede, 1991;

Schein, 2004) divide culture into different levels, extending the number of levels by dividing the two main levels—visible and non-visible aspects of culture—into subgroups.

Hofstede (1991) proposes four layers with each layer representing a separate category, i.e., peeling back the layers of an onion reveals a deeper, hidden layer, with values ending up at the core of his model. The other three levels are rituals, heroes, and symbols. Schein (2004) offers a three-layer cultural model shown in Figure 1.

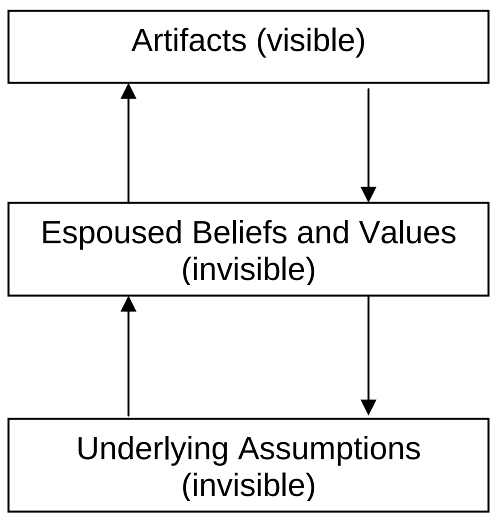

Figure 1. Levels of Culture (From: Schein (2004))

As seen in Figure 1, culture may be a function of artifacts, espoused beliefs and values, and underlying assumptions, developing and emerging from the dynamic interaction of these layers. To the extent that the layers fit and are congruent, then the culture is highly reflective of its artifacts and espoused values. Incongruence among variables may cause cultural dissonance, i.e., a society professing equality, yet not allowing women to work or drive. The next section uses Schein's model to discuss cultural layers in more detail.

1. Layer 1: Artifacts

Artifacts can be defined as the shell or the visible and concrete part of culture, often viewed as reflections of other deeper layers of culture, i.e., observed structures and data from the five senses. This category generally contains the architecture of a physical environment, language, technology, products, artistic creations, style, clothing, emotional displays, myths, stories, published list of values, observable rituals, and ceremonies (Dyer, 1985; Schein, 1999, 2004)

Although artifacts are easier to observe than other layers of culture and may appear to be easy to understand, Schein (2004) points out they may be difficult to decipher. An example is Egyptian and Mayan pyramids. The meaning of the structures in both societies was different, even though both resemble a similar pyramid shape. For the Egyptians, pyramids were tombs, and for the Mayans, pyramids were both tombs and temples. Therefore, care must be taken deriving meaning from artifacts, especially in different societies (Schein, 2004). Insider interpretations can be tacit and accurate compared to outsiders interpretations of the same data.

Artifacts can be helpful indicators for interpreting organizational culture including strategic direction. Amy (1990) conducted a cultural analysis of NASA by focusing on the language that NASA used to project its public image. She divided NASA's history into Era One, the Apollo Era (1958-1969); Era Two, the Transition from Apollo to the Shuttle Era (1970-1981); and Era three, the Shuttle Era (1982-1986). She analyzed what kind of words and how frequently these words were used in NASA's various publications. The changes that occurred in language were seen as indicative of changes in NASA's cultural perspectives, values, and assumptions. She concluded that the use of significant words or phrases in NASA documents changed over the three areas in two ways. The first change entails how the key terms were associated with other words. The second change occurred in the frequency of word use. One of the

conclusions was that the definition of the key term “environment” changed over three eras, and the relationship with the “environment” also changed for NASA. In Era One, “environment” is used to refer to space “environment,” in the Second Era, it meant the space as well as the organizational “environment,” and in the Third Era, it related only to the organizational “environment.”

Observers’ own feelings, knowledge, and assumptions can affect interpretation of artifacts. In other words, one’s own culture may distort the true meaning of artifacts from another culture. To get the true interpretation of artifacts, gaining insight of deeper levels of culture and evaluating artifacts together with beliefs, values, and assumptions are necessary (Schein, 2004).

2. Layer 2: Beliefs, Values, and Norms

Beliefs, values, and norms are often abstract and may constitute invisible parts of culture. Norms tell people (employees) how to behave under various conditions or circumstances, e.g., always wear a coat and tie. Morris (1956) defined norms as “generally accepted, sanctioned prescriptions for, or prohibitions against, others’ behavior, belief, or feeling, i.e. what others ought to do, believe, feel—or else” (p. 610). From an organizational perspective, norms are socially created expectations about which behaviors are acceptable and unacceptable. They are unconsciously accepted and used to guide behavior and to interpret the behavior of others. Norms also provide a sense of “ought-to-be” values. They can motivate group members and help them to rationalize their behaviors to achieve an expected outcome. Hofstede (1994) defined values as “broad tendencies to prefer certain states of affairs over others” (p. 8).

Norms and values—sometimes used interchangeably in cultural studies - are different from each other, and Morris (1956) defines the basic differences as follows:

Norms include sanctions and values never do. Values can be held by one single individual, norms cannot. Values have only a subject—the believer—while norms have both subject and object—those who set the prescriptions and those to whom it applies. (p. 610)

Morris further explains that commonly held or established values often result in the formation of norms, but some norms may not depend on established values. Norms are accepted as assumptions by the group members.

3. Layer 3: Assumptions

Schein (2004) describes the process of development of an assumption in a group. He offers that once a group is formed, it faces new tasks, issues, or problems. Someone in the group offers a solution, and the group tries it in similar conditions until they believe in the reliability of the solution. After the group is convinced, they treat the solution as an assumption. In Schein’s view, the group develops assumptions to solve its internal integration issues in distributing power and influence, in developing desired peer relationship and intimacy, in rewarding and punishing certain kinds of behavior.

The environment can set limits on what a group can do, and unpredictable and unexplainable events occur in turbulent environments. A group can also develop assumptions to help its members in handling environmental uncertainty and the pressure it creates. In short, a group can use assumptions as a collective defense mechanism to cope with both internal and external issues. Assumptions may not be negotiated as long as the actions resulting from the assumptions work out. When the group notices the old assumption is not reliable, it tries to develop a new assumption over time in a trial and error process.

NASA management, after the Moon landing, faced budget constraints. They developed the assumption that if they successfully reduced the cost of space exploration by designing reusable shuttles and accessing the space routinely by increasing the number of space flights, Congress would support

them. They developed reusable shuttles, and made routine flight schedules. They continued to follow the scheduled flights, although the o-ring and the foam problems had occurred in previous flights. After many successful missions with the o-ring and foam problems, NASA developed another assumption in which the o-ring and foam problems were not seen as significant risks justifying delay of the shuttle flights. These culturally driven assumptions may have contributed to the Challenger and Columbia shuttle disasters. NASA was perhaps unable or unwilling to change its assumption about flight safety after the first Challenger accident. Ott (1989) and Schein (2004) argue that looking at the underlying assumptions, which are at the essence of culture, is the most fruitful approach to culture. Without uncovering assumptions, cultural studies produce nothing.

C. WHY IS CULTURE IMPORTANT?

Organizational culture is arguably one of the most important forces affecting the overall performance of organizations. Culture's remarkable influences appear to affect organizational leadership, decision-making, performance, internal development, and strategic development areas (Howard, 1998; Quinn et al., 1991; Schein, 1996, 2004). Simircich (1983) emphasized the internal role of culture by referring to the following roles it plays: organizational culture is important in creating a sense of identity, promoting organizational commitment, enhancing social system stability, and serving as a sense making device that can guide and shape behavior.

The open *systems* view of an organization extends the internal role of culture by adding another vital role: mediation in adaptation to the environment. A system is defined as a set of interrelated components working towards a common purpose (Senge, 2006), and the relative fit or congruence of the components determines performance. A misfit between organizational culture and environmental factors or forces means performance will be degraded.

Schein (1992) concluded that merely adapting to the environment is not a guarantee for success, rather an organization must try to influence and manage its environment.

Culture may be a fundament factor in the success of human-capital intensive, scientific organizations with a primary source of value being intellectual capital rather than material assets. Motivating and maximizing intellectual capital may require a thorough understanding of culture. For example, Southwest Airlines believing that “the company is only as good as its people” places much value on its people (Zellner, 1995). The critical task in Southwest was to keep airplanes flying with minimal turnaround time, requiring speed, teamwork and initiative (Rechard, 1994). To guarantee that it gets the right people, Southwest is extraordinarily selective in its recruiting. Evidently, if someone uses the word “I” too much in the interview, they are not hired (Chakravaty, 1991). Sometimes, even customers are involved in interviewing new flight attendants. It was very important to select the best person fitting the culture of the company. During Southwest’s hiring process, attitude is more important than skills because skills can be changed with training but attitudes are extremely difficult to change (Chakravaty, 1991). All new hires go through an extensive training in which they are exposed to the history, principles, values, mission, and culture of the company. To generate the emotional contact necessary to change, the entire flight crew team lives for a period of time together cut-off from phones, cars, and contact with the outside world. Then each team develops an action plan to ensure that their new behaviors are transferred to the work setting (Chakravaty, 1991).

Southwest successfully made the case that preserving the airlines culture was critical for performance. As the company got larger, employers were encouraged to think small, focusing on their immediate customers. In sum, Southwest has developed and maintained a culture of hard work, cost-consciousness, dedication, customer service, and teamwork. The company’s

focus on these cultural characteristics helps the company to reduce employee turnover, to be the cost-leader in its niche market, and to gain one of the biggest returns on investments.

NASA is similarly a knowledge-based, scientific organization assuming that scientific knowledge and technical skills are the key success factors to space travel. NASA developed a “can-do” culture in the early years of the agency between 1958—1972 by placing high value on the accumulation of scientific and engineering skills necessary to explore space. Testing and careful approach to every detail were another cultural assumption that contributed to high performance. In a relatively short time, NASA was seen as the most successful and reliable government agency and became known throughout the world for its successes in space exploration.

Culture is a two edged sword, also posing a substantial barrier to organizational change. As organizations evolve and change over time, their cultures also evolve, although more slowly (Davis, 1982; Meek, 1988; Schein, 2004). Leaders would therefore be advised to diagnose their cultures, and to positively influence them by ensuring their interventions are congruent among important variables, i.e., environmental factors aligned with direction, aligned with design factors. Without leadership and alignment, culture can be a contributing factor to failure through resisting change and/or dysfunctional behaviors (Heskett & Kotter, 1992).

Analysis of how culture contributes to critical events at certain times can be conducted by considering organizational history. Pettigrew (1979) has suggested that “the point of studying a sequence of social dramas longitudinally is that they provide a transparent look at the growth, evolution, transformation, and, conceivably, decay of an organization over time” (pp. 570-571). Ultimately, the history of a company has an influence on culture and organization.

Assuming the final and common goal of all management activities is to enhance performance by implementing effective control mechanisms, further discussion is provided about the role that culture plays as a social control mechanism and performance-enhancing tool in organizations.

1. Culture as a Social Control Mechanism

Culture can be a helpful tool or key variable in increasing the control function of management in the overall organization (Tushman & O'Reilly, 1997). Managers, especially those who view decision-making from a rational, empirical perspective, may perceive cultural analysis to be of little value. One reason is that culture is not readily visible and thus hard to measure (Schein, 2004). Merchant and Van der Stede (2003) have pointed out that management control includes "all the devices or systems managers use to ensure that the behaviors and decisions of their employees are consistent with the organization's overall objectives and strategies" (p. 4). Culture is one of those devices.

The expected benefit from management control systems is to increase the possibility of reaching organizational objective(s) by influencing behaviors of employees in a desirable way. Examples of formal management control systems are financial planning systems, budgets, inventory control, and safety programs. These formal control systems are designed to guide employee behaviors. For example, a marketing department controls its cost to comply with the planned budget.

Although managers design and employ formal control systems to prevent undesirable behaviors, they may not ever be able to eliminate all of the control problems (Merchant & Van der Stede, 2003). For this reason, managers in search of effective controls can become adept at diagnosing and influencing culture as a form of internal control (Merchant & Van der Stede, 2003; Tushman & O'Reilly, 1997). Culture is an invisible control mechanism operating in

employees' thought processes (Hall, 1984). When employees internalize the cultural characteristics of the organization, they act within the limits as set out by what is culturally acceptable.

Because culture influences how employees act, the process of cultural control can occur in the following way. Groups exert pressure on individuals who deviate from group norms and values. The group's cultural norms are embodied in written and unwritten rules that govern their behavior (O'Reilly &, Tushman 1997). Individuals in a group often monitor each other and thus pressure others to act consistently with the norms of the group. It is easy to conclude that if the norms and the objectives of individuals, groups, and the organization are consistent with each other, then the norms can serve as control mechanisms. Otherwise, norms that are inconsistent with the objectives of a company can confuse group functions and performance.

O'Reilly and Tushman (1997) have also suggested that if norms are shared widely and practiced widely, they can serve as a means of social control. Weak norms cannot easily create cohesion and commitment necessary for success.

2. The Role of Culture in Performance

Performance is a term used to show the degree of achievement of results, i.e., results as a product of contextual and design factors. Many factors (independent variables), such as technology, structure, resources, culture, size, and strategy, contribute to performance (dependent variable). In addition, contextual and design factors also affect each other; hence, it is difficult to measure which factors and how much they contribute to performance and what kind of a dependency they have among themselves. Furthermore, several authors have argued that culture should not be treated as a variable affecting the outcomes (Trice & Beyer, 1984; Meek, 1988; Sacmann, 1991). They have advocated understanding and interpreting culture in qualitative methods.

However, important and useful theoretical models, research, and studies have been done to find whether culture and performance have a cause-effect relationship.

Barney (1991) stated that organizational culture is an intangible resource and can lead to higher performance if it is leveraged and utilized in a consistent manner with organizational goal(s). Peters and Waterman (1982), in their book *In Search of Excellence*, examined characteristics of the most successful American companies and found that culture is a leading contributing factor to organizational performance. Gordon (1985) examined service sectors, such as banking and utilities, to determine the relationship between performance and culture, and his conclusion was that high and low performing companies have different cultural profiles. Hesket and Kotter (1992), by analyzing many companies in the United States, brought up two points: strong cultures, if aligned with contextual factors, enhance performance; and strategically or contextually appropriate cultures can promote long-term success if norms and values are consistent with the changing environment.

Schein (1996) made another point about the culture-performance relationship. He stated that subcultures, like dominant cultures, play a critical role in the efficiency and effectiveness of an organization. He generally classifies subcultures into three different occupational cultures: operators, engineers, and executives. These three occupational cultures have developed different occupational assumptions in handling their jobs over time. Operators include line managers and workers and are the target group of management efforts to train and change. Engineers design and monitor the technology that underlies what the organization does. The engineers’ assumption is that humans are more complex than machines and employing capable machines and utilizing technical solutions to problems is easier and preferable. Operators feel themselves threatened by engineers. The executives handling daily management activities developed the assumption that their role is financial accountability. To keep the

company financially viable, they unconsciously conflict with the other occupational groups when playing their role. Schein (1996) concludes that integration of occupational cultures would result in higher performance.

Hesket and Kotter (1992) have also suggested that “performance-enhancing cultures usually erode over time, either because they are not effectively passed on to the new management needed in a growing business or because time and success and other factors blur people’s memories about why they were successful in the first place” (p. 144). NASA, in the “man-on-the-moon” period, had a culture enabling it to obtain superior performance. This research analyzes why that performance was not passed on to new members, thereby resulting in apparent cultural and performance erosion over time.

The prevailing logic is that performance would be enhanced if the common behaviors and methods of doing business fit the company’s environment. Strong cultures that do not fit a company’s environment can lead intelligent people to behave destructively, undermining an organization’s ability to survive and prosper (Hesket &, Kotter 1992). Although NASA had a strong culture that fit its environment, supported its strategy, and thus contributed to its high performance between 1958—1972, NASA’s culture between 1996—2004 had a weak degree of fit with its environment and was not adequately aligned with its strategy and its systems. These misalignments may have contributed to the Columbia accident. Future chapters will describe and analyze these two periods of NASA culture in more detail.

To the extent that culture is “what the organization is about,” then it is worth analyzing and understanding. Culture also obviously affects people outside the organization in terms of customer interaction, vendors, contractors, and regulators. In the next chapter, McCaskey’s organizational framework and open systems theory are described to place culture in theoretical frameworks showing its relationship with other system components.

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III. OPEN SYSTEMS MODEL

This chapter applies McCaskey's organizational systems framework to describe NASA culture. Culture has been placed at the center of the model, using other components such as structure, task, people, and resources as explanatory variables to understand NASA's culture at different time periods. The extent to which key variables are aligned or incongruent will be analyzed and used to explain NASA performance during the two time periods of 1958—1972 and 1996—2004. The chapter also provides an overview of open system theory and McCaskey model components, including the importance of the alignment between design factors and organizational culture.

The value of using a systems approach for diagnosing organizational problems can be appreciated by managers, because they may have greater relative control over design components. People and tasks are two design components where managers typically have greater influence, i.e., managers are involved in hiring processes and *task* employees to do a myriad of things. These factors appear directly to affect human resource decisions and efficiency and productivity results (system outputs).

The McCaskey model is an organizational systems framework comprised of three basic parts, which all systems have in common: inputs, throughputs and outputs. The input section focuses on internal and external factors that create direction and set boundaries for the organization. Examples of external environmental factors include socio-economic, political and technological forces and trends. Typically, organizational leaders set direction through inputs such as mission, vision, goals, policies and strategies. Throughputs refers to the *black box of management,* where managers intervene in terms of job tasks, structure, technology, and people. A distinct difference between our model and the McCaskey model is that culture is being purposefully viewed as a part of the throughput process, interacting with other system components or design factors.

A. OPEN SYSTEMS THEORY

Open systems theory, according to Nadler and Tushman, is a general framework for conceptualizing organizational behavior over time. A system is a “set of interrelated elements,” and these elements are interdependent such that changes in the nature of one component may lead to changes in the nature of the other components (Nadler & Tushman, 1992). In other words, each component of the system interacts with each other and has the ability to influence other components. The distinct difference between an open versus a closed system is that a closed system has a minimal relationship with the external environment. There is a difference between components that reside inside the system and outside environmental factors trying to penetrate the system; however, deciphering between the inside components and external factors can be difficult.

Figure 2 shows a basic, open systems model. The McCaskey model is an open system because the system relies on its external environment for inputs to support the transformation process described by the model’s components or design format.

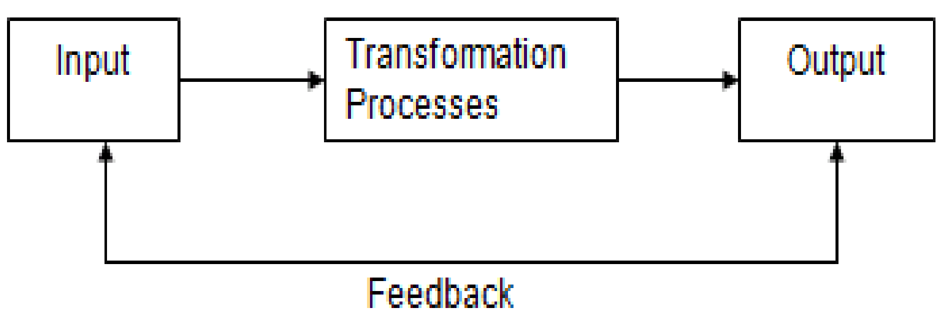

Figure 2. Elementary System Model (After: Nadler & Trushman (1992))

Closed systems can exist relatively independent of the external environment. An example of a closed system would be a terrarium, completely self-contained and insulated from the external environment (Nadler & Tushman, 1992). The self-containment of closed systems limits the amount of influence placed on the system from external factors such as the environment. An open systems approach works well for our analysis because NASA's external environment helped shape the organization. The modified McCaskey model is a useful tool to analyze NASA during the two periods because the model enables assessment of the degree of fit or alignment between culture and the system components during the two time periods.

Nadler and Tushman (1992) define congruence as the degree to which the needs, demands, goals, objectives, and structures of one component are consistent with the needs, demands, goals, objectives, and structures of another component. Thus, fit is a measure of congruence between pairs of components. The greater the degree of congruence between components, the better the fit between them. High degrees of congruence and fit result in more effective behavior at multiple organizational levels.

Effective organizational behavior is defined as behavior that leads to higher levels of goal attainment, utilization of resources, and adaptation (Nadler & Tushman, 1992). When systems are misaligned or incongruent, the organization will generally not perform at a level required by its stakeholders to be successful. The implications of the congruence hypothesis in this model is that managers continually diagnose their organizational system, determining the location and nature of inconsistent fits, then ensuring their intervening actions positively impact overall system congruence.

This research adopts open system theory and the McCaskey's model because they provide a solid theoretical foundation for analyzing organizational behaviors, particularly in terms of performance. Furthermore, the models can

help explain organizational failures by assessing the degree of fit between culture and the system components. Figure 3 shows the modified model and its components.

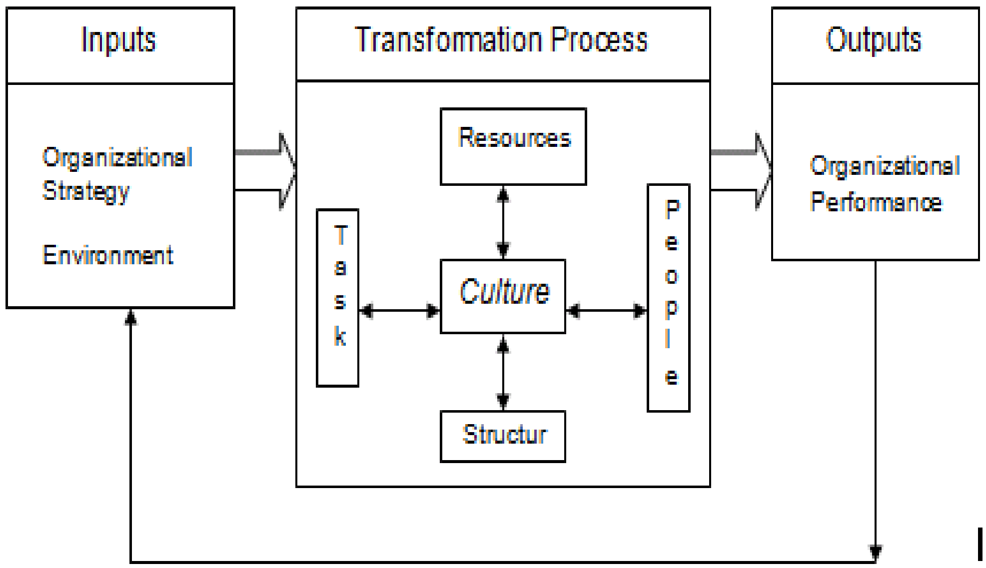

Figure 3. The Modified Model (After: Nadler & Trushman (1997) and Roberts, 2000)

B. OPEN SYSTEMS MODEL — MODIFIED

1. Input

In the modified McCaskey model, the inputs that influence organizational behavior are the external environment and NASA's organizational strategy. The environment comprises both external and internal factors. Examples of external factors are markets, government, and competitors. External factors, which appeared to influence NASA greatly, are U.S. government policies and competition from other countries, particularly the USSR. The President outlines the overall National strategy and agenda, which is then communicated to the agencies responsible for implementing a plan of action to support the direction given. Congress is charged with ensuring each agency's objectives are aligned

with the President's by passing the budget that allocates the funds used by the agencies. When President Kennedy announced that the US would place a man on the moon by the end of the decade, it placed tremendous pressure on NASA to ensure the mission was accomplished. At that time, Congress appropriated the dollars for the mission and there was strong public support as well.

Laws and government regulations can affect organizational behaviors, including regulatory, hiring and funding constraints. For example, when Congress authorized the establishment of NASA the organization had the legal authority to seek space exploration. NASA was also given the legal authority to spend money on space exploration by way of appropriated funds passed by Congress and signed by the President.

Competitors can also be an important external factor in that successful organizations are likely to experience direct competition, i.e., the United States and the USSR were competing in a space race, and political and public perceptions between 1958—1965 was that Russia was winning the race. Losing the space race became unacceptable and drastic measures were deemed necessary. The formation of NASA and the significant funding provided to complete the Mercury, Gemini, and Apollo projects were two sizable measures the US employed to overtake the USSR in the space race.

Some organizations continually adjust and redefine their industry positions, including their relationship with society. One way an organization defines itself is through their strategic plans and intentions including their mission, vision and strategic objectives. An organization's mission statement is meant to summarize their strategic competencies and how those competencies relate to its goals. A vision statement may project broader ideals and values deemed important for accomplishing long term goals. Strategic objectives often describe how an organization intends to accomplish its mission, vision and goals. Therefore, an organization's most crucial input can be its intended direction, summarized through its espoused mission, vision and strategic goals (Nadler & Tushman, 1992). NASA was formed to re-establish US dominance in space and

science. Therefore, the strategy developed for NASA in the early stages was fairly specific aimed at manned-space flight. After the “Moon Mission” was accomplished, NASA had some difficulty redefining its organizational strategy, clarifying its new mission, and reworking its strategic objectives.

2. System Components

a. Task Component

Primary system components comprising the McCaskey model are task, people, organizational structure, and resources. The logic is that NASA’s performance would be greatly affected in terms of assigned tasks, the knowledge, skills and abilities of its scientists and engineers, how it structures or coordinates its complex activities, and resource availability.

The task component examines the nature of the task and the extent and nature of interdependence between task performers. Simply put, the task design factor focuses on the “work” that is being done It can be important determining the extent to which tasks are related to organizational rewards, because rewards can signal task prioritization, including what does not get done. The relationship between organizational rewards and priorities matters because if organizations reward employees for actions that do not focus on organizational objectives, then stakeholder needs and expectations may suffer, thereby resulting in degraded performance. If the tasks at NASA did not support the advancement and success in space exploration, then it would risk funding reductions as well as negative publicity, all of which would impact organizational culture. Congress attempts to appropriate funds to agencies whose objectives and performance are aligned with National Strategy, including serving public interest.

Organizational culture can impact tasks both in terms of determining which tasks are actually performed and how they are performed. Again, the notion of congruence is the central theme in that the extent to which

tasks are tied to organizational objectives and rewards, including the type of culture needed to accomplish all its critical tasking, then organizational performance will be high.

There are three specific ways of analyzing how work flows within an organization. Work is either pooled, sequential, or reciprocal in which each type of interdependence has distinct characteristics that affect the congruence between the other system components. Pooled interdependence is considered to be the simplest form to manage due to a lack of coordination needed between the systems and structures affected. According to Tushman and O'Reilly, pooled interdependence exists when component tasks have no linkage with one another; that is, each subunit does its own work, and the larger system's performance is simply the sum of each subunit's output. The early years of NASA provides an excellent example of this type of interdependence. Each of the centers under the NASA umbrella was responsible for separate components; however, the consolidated product was credited to NASA. Chapter IV provides greater detail as to what tasks each center was responsible for during NASA's early years. Sequential interdependence exists when component tasks are linked in a linear sequence (Tushman and O'Reilly, 1997). Each unit is directly dependent on the unit preceding it; this dependence is similar to an assembly line. Reciprocal interdependence exists when each component task is inherently linked to other tasks; that is, the completion of one component task is dependent not only on the preceding task but also those that follow (Tushman & O'Reilly, 1997). Reciprocal interdependence is more complex and is dependent on the use of interlinked feedback loops that provide for the needed collaboration, teamwork, and trust to accomplish the job task. Figure 4 provides a simple diagram of how each one of the interdependencies are designed to operate.

After NASA's start-up and particularly during the Project Apollo period, the organization's work required reciprocal interdependence due to the complexity of its mission. Space exploration is highly technical and thus requires significant collaboration to complete complex tasks. This collaboration is

exemplified in NASA's use of project teams consisting of engineers, scientists, and contractors working in separate areas of the organization.

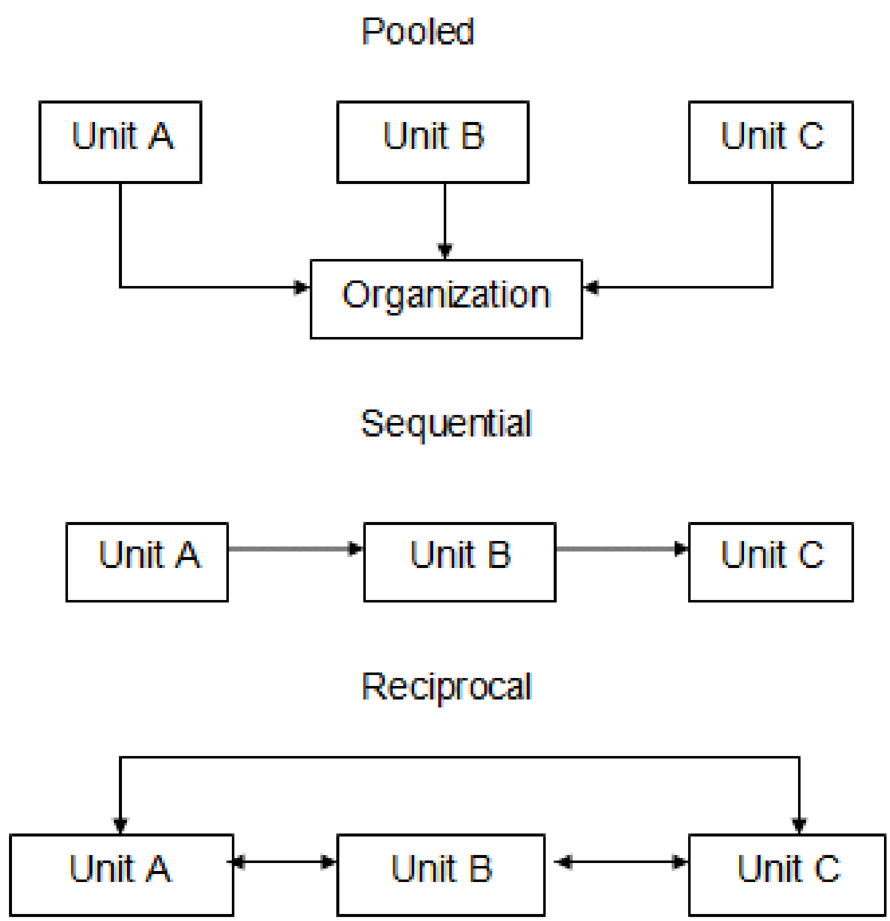

Figure 4. Type of Interdependencies (After: Nadler & Trushman (1997))

b. People Component

The people component refers to individuals comprising the organization including how many, demographic diversity and types of education and skills needed. This component raises two fundamental questions: What knowledge, skills, and abilities do people bring to work, and how does the organization attract and retain talent? These two questions are vital to an

organization when developing the workforce. What is also important are the motivations behind the individuals seeking employment as well as their expectation of how they will be treated as employees.

NASA required highly skilled workers to complete its projects; furthermore, the culture had to support the needs and expectations of these people to hire and to retain them. In other words, an organization can seek prospective workers who have values, beliefs, and personalities that fit well with the culture. In short, the people component and organizational culture become a crucial area of alignment for producing high performance.

Organizational demographics refer to employee factors such as age, gender, and cultural backgrounds. The greater the demographic differences, the greater the potential for team conflict (Tushman & O'Reilly, 1997). However, diversity has been seen by some human resource professionals as an organizational strength, particularly when innovation and creativity are needed. In a work environment that demands highly skilled scientists and engineers, it could be a challenge also trying to balance diversity factors.

NASA attracted top scientists and engineers from around the world. The organization's interest was talent rather than age, gender, or cultural background. This attitude created a culture of hiring highly intelligent, results oriented people. Also, the internal and external environment created a culture of constant pressure; therefore, the managers, engineers, and scientists NASA hired had to be equipped to handle these pressures.

Beyond competencies, managers can gather data on individual differences in motivation so that they can design reward systems that are aligned with both individual needs and critical tasks (Tushman & O'Reilly, 1997). As indicated earlier, it is vital for managers to assess the motivations of their subordinates to put in place the correct reward systems aligned with individual needs as well as critical tasks. According to David McClelland's theory of needs;

an individual's motivation and effectiveness in certain job functions are influenced by *achievement*, *affiliation*, or *power* (McClelland, 1961). People with a high need for achievement seek to excel. Individuals with a high need for affiliation need harmonious relationships with other people and need to feel accepted by those people, although people from different organizational and national cultures define harmonious relations in different way. Those in need of power may seek personal power over others, or the more beneficial need of having power to organize the efforts of others and to achieve organizational goals. The culture created from professionals with high achievement needs values task completion and mission accomplishment.

c. Structure Component

Organizational structure often defines roles and functions, including the following main components:

- It designates formal reporting relationships, the number of levels in a hierarchy, and the span of control of managers and supervisors.
- It identifies grouping of individuals into departments and of departments into the total organization.
- It determines the design of systems to ensure effective communication, coordination, and integration of efforts across organizational departments (Daft, 2004).

Culture and structure have no known specific relationship (Baligh, 1994). However, culture over time becomes ingrained in the major processes and structure of organizations (Schein, 1999). From Schein's point of view, the elements of formal organizational structure, such as the division of labor, decision-making processes, hierarchy of authority, control mechanisms, rules and regulations, norms, and job descriptions are also indications of organizational culture.

According to Mintzberg: "effective organizations achieve coherence among their component parts, [when] they do not change one element without considering the consequences to all of the others" (1979, p. 103). Span of

control, degree of job enlargement, form of decentralization, planning system and matrix structure should not be picked and chosen at random. Furthermore, these structural features should be selected to be consistent with the organizational context such as its age and size, the condition of the industry in which it operates, and its production technology.

Minztberg (1979) classified the configurations of organizations into five groups: simple structure, machine bureaucracy, professional bureaucracy, divisionalized form, and adhocracy. Each configuration is distinct in structural factors and situation, and the fit between structure and culture can be considered in designing organizational coordinating mechanisms. For example, NASA required a culture of safety and risk aversion during the Columbia period; however, the safety division was not independent and reported to the same managers to whom the division provided recommendations for safe flights. Table 1 shows the fundamental characteristics of the five organizational configurations.

	Simple structure	Machine bureaucracy	Professional bureaucracy	Divisionalized forms	Adhocracy
Key means of coordination	Direct supervision	Standardization of work	Standardization of skills	Standardization of outputs	Mutual adjustment
Structural elements					
Specialization of jobs	Little specialization	Much horizontal and vertical specialization	Much horizontal specialization	Some horizontal and vertical specialization(between divisions and headquarters)	Much horizontal specialization
Training and indoctrination	Little training and indoctrination	Little training and indoctrination	Much training and indoctrination	Some training and indoctrination (of division managers)	Much training
Formalization of behavior-bureaucratic/organic	Little formalization-organic	Munch formalization-bureaucratic	Little formalization-bureaucratic	Much formalization (within divisions)-bureaucratic	Little formalization-organic
Grouping	Usually functional	Usually functional	Functional and market	Market	Functional and market
Unit size	Wide	Wide at bottom, narrow elsewhere	Wide at bottom, narrow elsewhere	Wide at top	Narrow throughout
Planning and control system	Little planning an control	Action planning	Little planning and control	Much performance control	Limited action planning (esp. in administrative adhocracy)
Liaison devices	Few liaison devices	Few liaison devices	Liaison devices in administration	Few liaison devices	Many liaison devices throughout
Decentralization	Centralization	Limited horizontal decentralization	Horizontal and vertical decentralization	Limited vertical decentralization	Selective decentralization
Situational elements					
Age and size	Typically young and small	Typically old and large	Varies	Typically old and very large	Typically young (operating adhocracy)
Technical system	Simple not regulating	Regulating but not automated, not very complex	Not regulating or complex	Divisible, otherwise like machine bureaucracy	Very complex, often automated(in administrative adhocracy) not regulating or complex (in operating adhocracy)
Environment	Simple and dynamic; sometimes hostile	Simple and stable	Complex and stable	Relatively simple and stable; diversified markets (esp. products and services)	Complex and dynamic; sometimes disparate (in administrative adhocracy)
Power	Chief executive control; often owned managed; not fashionable	Technocratic and external control; not fashionable	Professional operator control; fashionable	Middle-line control' fashionable (esp. in industry)	Expert control; very fashionable

Table 1. Dimensions of the five configurations (After: Minztberg (1979))

Minztberg (1979) admits "none of the structural configurations so far discussed is capable of sophisticated innovation, the kind required of a space agency, an avant-garde film company, a factory manufacturing complex prototypes, or an integrated petrochemicals company. The simple structure can certainly innovate, but only in a relatively limited way as the chief innovator is often the owner, manager and the CEO. Both the machine and professional bureaucracies are traditional hierarchical bureaucracies, designed more for stability and predictability rather than to solve new and complex problems. While the divisionalized form may be perfect for expanding using new divisions, it suffers from the functional redundancy and strategic inflexibility inherent in machine bureaucracies.

NASA appears to reflect an adhocracy organizational structure, noting the difficulty for classifying any complex organization using a single description. Adhocracy is known for its flexibility, apparently needed in organizations that must innovate and adapt quickly using diverse, expert talent. Administrative and operating types are two different forms of an adhocracy structure. The administrative type develops and carries out projects in the name of the organization. The operating type works on projects created by third parties, and aims to create tailored solutions for well-defined issues. Also, an adhocracy relies on specialized experts to work together to develop innovative products. Therefore, power is fluid throughout the organization and is given to the specialists as well as management depending on project status. Another distinct difference of an adhocracy is that a project manager does not directly supervise a team. Rather s/he is considered a contributing member of the team with additional duties surrounding inter-team coordination.

d. Resource Component

The resource component is comprised of the people, technology, financial resources, and industry capabilities available to the organization. Implicitly, this design factor describes what assets are available and used by the

organization to fulfill its mission. People are the human resources of the organization comprising its intellectual capital. Obviously, intellectual capital is crucial to the extent that the organization must create new solutions to new problems, including the ability to motivate and retain specialists.

Technology is also considered an organizational resource because it can enable the organization to be innovative and more efficient. There are many circumstances when an organization mixes people and technology to complete complex tasks. For example, management information systems are often used in the public sector to capture droves of data, which then must be transformed into usable knowledge to assist decision makers in their governance tasks.

Financial resources can include liquid capital, facilities, and organizational equipment and patents. The primary financial capital available to NASA is appropriated funds from the President's annual budget. These funds are used primarily for operating expenses as well as investment in research and development opportunities. Also, NASA partnered with other U.S. companies and other countries on projects to defray overall costs and liabilities. An example of a consolidated effort in a major project would be the development and sustainment of the International Space Station. Chapter IV provides some details concerning NASA's major contractors.

e. Culture Component

Although each separate system component can appear individually vital to organizational success, what is paramount is the interrelationships and interdependencies of the components creating a holistic system. The premise of this study is that organizational culture serves as the nucleus or the glue that holds the system components together (see Figure 2). As depicted in Figure 2, culture affects and is affected by each system component during the transformation process. Culture is ingrained in every system component of the transformation process, and for an organization to operate effectively the various

components either work towards a common purpose, or become fragmented, i.e., tasks and organizational cultural alignment are crucial for success. The critical job tasks simply cannot be in conflict with cultural norms, including the people component being congruent with organizational culture. This means that the right person with the right skills is in the right job, and is supported and encouraged to perform based on structural and cultural congruencies. People with similar work values, achievement needs, and motivations can create a whole greater than the sum of its parts. Performance gaps can occur when the formal structure is not aligned with organizational culture. For example, if an organization is operating in a matrix structure known for violating the principle of unity of command, then the culture would need to be accepting and skilled in handling the accompanying conflict. When NASA's culture began turning more bureaucratic in the 1980s, the structure remained relatively flat, possibly creating performance issues. And lastly, culture and resources must be congruent with one another to ensure that the resources are being used and expended consistent with the norms and values of the organization. When an organization espouses high ethical norms, then activities like embezzling and Anti-deficiency Act (ADA) violations would introduce gaps in terms of intended and actual behaviors.

3. Outputs

The primary output of which this research is concerned is successful organizational performance, including what factors appear to relate to performance, and performance measurement or success criteria. Performance in the private sector is more easily measured in financial terms of profit and return on investment. When a public sector organization measures performance financially, it might focus instead on financial inputs, or the amount of money appropriated. If a public organization overspends or underspends, it may incur an ADA violation in the former, and have its budget reduced the following year in the latter.

An example of a non-financial measurement used in the public sector is how efficient the organization accomplishes or is perceived to accomplish its goals. Efficiency can sometimes be measured in terms of outputs over inputs. Also, when organizations become proactive in minimizing waste, then they are attempting to become more efficient.

Open systems theory posits that if there is substantial congruence among all major system components, then organizational performance will be high. This study analyzed two different periods in NASA's history, 1958–1972 and 1996–2004, to ascertain the role of cultural congruency in impacting two different performance attainment periods.

Described in the next chapter is NASA's culture and how it was created in its infancy stages. Specific system component characteristics of task, people, organizational structure, and resources prevalent in NASA during the 1958–1972 period are also examined. Finally, how those components influenced and were influenced by NASA culture is also described using a modified McCaskey model (Figure 2). This assessment enables diagnosis of the degree of alignment between system components possibly leading to different performance characteristics in NASA during two periods.

IV. NASA CULTURE: TASK, PEOPLE, RESOURCES AND STRUCTURE ALIGNMENT 1958 TO 1972

This chapter explains the formation of NASA as a space exploration organization and describes cultural factors from 1958 to 1972, including the degree of alignment of cultural attributes with organizational tasks, people, resources and structure.

NASA's process of creation is different from that of other governmental and private organizations in that it was not created "from scratch." It evolved from the core of the National Advisory Committee for Aeronautics (NACA), and later it expanded by incorporating new groups from military organizations such as the Army Ballistic Missile Agency (ABMA), Jet Propulsion Laboratory (JPL), and the Vanguard Group of the Naval Research Laboratory. In addition, when NASA was given the mission of putting a man on the moon in 1961, the Johnson Space Center (originally called the Manned Spacecraft Center) in Houston and the Kennedy Space Center in Florida were built to make the agency capable of attaining its moon landing goals.

Naturally, the pre-existing organizations incorporated into NASA had their own cultural attributes and history. Consequently, the building blocks of NASA's culture came from these prior organizations, resulting in NASA's culture developing as a confederation of these pre-existing organizational cultures (McCurdy, 1993). The variables of NASA's culture from 1958 to 1972 are described to show how various characteristics likely contributed to the successful moon landing task.

In the second part of the chapter, the degree of alignment of NASA's culture with the other organizational components—task, people, resources and structure—are discussed since cultural variables alone can provide only a partial explanation of successful organizational performance. The theory is that the

extent of congruence among internal and external variables generates or contributes to an emerging organizational culture which positively impacts overall organizational performance (O'Reilly & Tushman, 1997).

A. ORGANIZATIONAL FORMATION OF NASA AND ITS CULTURE (1958-1972)

1. The Contribution of National Advisory Committee for Aeronautics (NACA) and Military Services to NASA

NASA was established by "The National Aeronautics and Space Act" on October1, 1958, with the peaceful purpose to explore the benefits of "space" for all mankind.[4] The process of establishing NASA was different from the traditional formation of an organization in that it was not created "from scratch" by hiring new employees, buying new equipment, or building brand new facilities. It emerged from three "already existing" organizations.

One of the "already existing" organizations included in NASA was the National Advisory Committee for Aeronautics (NACA). The U.S. Congress established National Advisory Committee for Aeronautics (NACA) "to supervise and direct the scientific study of the problems of flight, with a view to their practical solutions" in 1915 during World War I (McCurdy, 1993, p. 12). Although NACA pursued technically correct solutions to flight engineering problems, the space activities in the United States would benefit in later years because of this agency's research and skills. In other words, the road to space research originally started with the formation of NACA.

To support NACA in developing aircraft engines, Congress created three laboratories over 20 years: the Langley, Ames, and Levis laboratories.

The Langley Memorial Aeronautical Laboratory (Langley) was established on a Virginia army base in 1920, primarily headed by engineers. This center,

[4] For more information: National Aeronautics and Space Administration, History Division, http://history.NASA.gov/spaceact.html, (accessed September 2007).

when transferred to NASA and was in charge of human space flight programs during NASA's early years (1958–1963). A Special Space Task Group was in operation in Langley to supervise work on the Mercury space capsule which was one of the small-scale projects of the new space agency. Later, the laboratory sent its Space Task Group to the Houston Space Center. Langley also contributed to the establishment of the Flight Research Center (FRC) when it transferred a group of its engineers to FRC.

The second laboratory created by Congress, the Ames Aeronautical Laboratory (Ames), was established in 1939 at Moffett Field in California to complement the work of Langley during WWII. The nucleus of Ames was again a group of engineers transferred from the Langley Laboratory who would lead this new laboratory. The core activity at Ames was high-speed flight research. Experts at Ames did preliminary work, which guided NASA in design of spacecraft.

One year later, in 1940, the third laboratory, the Lewis Flight Propulsion Laboratory (Lewis) was added to the chain of NACA's laboratories. Lewis was created in Cleveland, Ohio, to conduct research on aircraft engines. A research group at Lewis was able to develop a high-energy technology called the liquid-hydrogen-fueled rocket, which contributed to NASA's ability to reach the moon (McCurdy, 1993).

The last research center of NACA was the Flight Research Center (FRC), which is now known as the Dryden Flight Research Center. It was established in 1946 in the same way as prior laboratories by transferring a group of Langley engineers and technicians to facilities in Southern California's Mojave Desert. This facility studied the dynamics of high-speed flight (McCurdy, 1993). FRC, with the Air Force and Bell Aeronautics, tested the Bell XS-1, a cigar-shaped experimental aircraft propelled by a rocket engine that consumed liquid oxygen and diluted alcohol (McCurdy, 1993). During 20 years of research and testing, 12 aircraft were crushed and four test pilots died. These accidents reinforced the

notion that testing experimental aircrafts is inherently dangerous and accidents are part of this process. This reality would be further strengthened due to additional accidents, thereby infusing this orientation deeply into NASA's culture.

Each of these NACA research laboratories contributed to solve one aspect of space flight problems when the labs became part of NASA due to the Space Act in 1958. The Langley, Ames, and the Lewis laboratories provided the United States with its premier institutions for flight research in the building of space capabilities.

McCurdy (1993) points out that these centers "maintained the culture of the research laboratory, of the engineers in charge, of the triumph of technology and scientific inquiry for problem solving" (p. 13). They maintained a tradition of technical detachment. Furthermore, their geographically isolated and distant locations kept these laboratories away from the politics of Washington, and, perhaps most importantly, the NACA laboratories did not have to report directly to the NACA headquarters in Washington, D.C. In addition, NACA had a small staff in its headquarters in Washington, which helped the laboratories to do their jobs without the pressure of politics and bureaucracy.

As indicated earlier, The Space Act attached all these NACA research laboratories to NASA. In addition to these laboratories, NASA acquired staffs and facilities from the military services. From the Army, approximately 4,500 employees, the big portion of the Army Ballistic Missile Agency (ABMA) under the leadership of German rocket scientist Wernher von Braun, were transferred in April 1960 to NASA's newly opened Marshall Space Flight Center in Huntsville, Alabama. The von Braun team had successfully placed the first American satellite in orbit in 1958 before joining NASA.

The von Braun team had a unique origin. It was originally formed in the 1930s in Germany to develop a long-range rocket against Great Britain which was successfully launched in 1943. When the war ended, most of the rocket

engineers surrendered to the American troops, and were brought to the United States to continue their prior research on rocket development under the control of the Army Ballistic Missile Agency (ABMA) in Huntsville, Alabama.

The Army rocket team and its approximately 4,500 supporting employees were incorporated into the NASA's newly opened Marshall Space Center. The rocket team brought its own cultural attributes into NASA. They were meticulous in their work, evidently strongly believing in the importance of close attention to details, including the continual development of improved rocketry. The rocket team apparently believed that the key to success was having complete control over projects and doing as much work as possible with their own staff. This habit became prevalent when the Army sent them to the Army Redstone Arsenal, a place for manufacturing munitions (McCurdy, 1993). Between 1950 and 1956, the rocket team developed the Redstone rocket with its own staff at Redstone Arsenal, which was used for the first live nuclear ballistic missile tests conducted by the United States. The army rocket team then developed the Jupiter-C, a modified Redstone rocket. The Jupiter-C successfully launched the first American satellite, Explorer 1, on January 31, 1958.

The second group transferred from the Army to NASA was the Jet Propulsion Laboratory (JPL), located in California. NASA also took control of JPL facilities in 1958. This laboratory was first established as a research laboratory in 1943 for aeronautics and rocketry under the California Institute of Technology. This university was one of the nation's best-regarded science and engineering research universities. JPL had a tradition of working closely with scientists outside the laboratory. As an example, James Van Allen of the University of Iowa discovered the radiation belts encircling earth. The radiation belts bear his name and are now known as the Van Allen radiation belts. After 1940, JPL was turned into a contract operation for the U.S. Army. JPL worked with the Army Ballistic Missile Agency to develop the first U.S. satellite, Explorer 1.

JPL mostly dealt with unmanned flight issues in NASA with strong commitment to scientific research. The employees of JPL established their fame

as scientists who could send out probes to explore the solar system. They developed the Ranger and Surveyor probes that helped chart moon landing sites, thus enabling astronauts to land at predetermined moon locations, including developing the Mariner probes that visited Venus, Mercury and Mars. The Voyager twins, which flew, by Jupiter, Saturn, Uranus, and Neptune were also developed by them.

The development of the Deep Space Network by JPL was a breakthrough for space activities. Through this network, communication with probes traveling to other planets and their moons was established.

2. NASA's Expansion with New Centers toward Manned Space Flight

NASA, after the inclusion of the NACA's research laboratories, wanted to have the ability to conduct its own operations in space. Formerly, manned space flight was the responsibility of Langley in the hands of a Special Space Task Group. To separate manned space flights from research and science work at Langley, NASA created a new center in 1962 located south of Houston devoted to manned space flights and moved Langley's Special Space Task Group there (McCurdy, 1993). This center, later renamed the Johnson Space Center in 1973, housed the Mission Control Center from which manned space flights were directed.

The Space Task Group logically brought aspects of NACA's culture into the Johnson Space Center. Cultural attributes included the primary focus on research and testing, seeking technical solutions to space flight problems with minimal outside interference, and taking calculated risks to improve flights. These cultural features arguably contributed to the successful development of the Apollo space capsule, the lunar landing module, and the space shuttle orbiter. However, to build these complex ships, the Johnson Space Center had to rely heavily upon contractors, and thus it deviated from NACA's "doing work in-house" culture.

In fact, NASA built new facilities, the Goddard Space Center, in Maryland with the original intention of establishing both manned space flights with the Langley's Space Task Group, and unmanned programs with the Vanguard Group of the Naval Research Laboratory, at the same center. Later, because of the moon-landing goal created by President Kennedy, the manned space flight program gained priority. The NASA management decided to shift the manned space program to the Johnson Space Center in Houston. Thus, the new facility in Maryland was left to be used only for unmanned flights.

The Vanguard Group, while in control of the Navy, was working on a small scientific satellite in an in-house government facility in Washington, D.C. for the Department of Defense. It had a tradition of in-house work culture like the NACA research laboratories. The Vanguard Group moved from the Naval Research Laboratory to NASA's Goddard Space Center with the Space Act.

NASA still needed to expand to be capable of manned space flights. As a consequence, NASA built its own launch facilities on Merritt Island in Florida. In the beginning, the agency used the Air Force launch capability at Cape Canaveral, Florida, the same facility that the von Braun team had been using to launch rockets since 1950. The construction of NASA launch facilities began in 1963, and NASA conducted its first launch from the Merritt Island facility for Apollo spacecraft in 1967[5]. This facility took the name of the Kennedy Space Center and was organized by the Marshall space flight team. The management of the center was given to the von Braun team.

Finally, the last center NASA built was the Stennis Space Center (Stennis) in Mississippi. This location was chosen due to its water access which provided easy transportation of large rocket stages, components and propellants. The Stennis Space Center was designed to be the site of a test facility for launch vehicles to be used in the Apollo manned lunar landing program. The flight certification of the Saturn V rocket, which was used in the Apollo 11 mission that

[5] See for more information: National Aeronautics and Space Administration, http://www.nasa.gov, (accessed October 2007).

landed the first men on the moon, was done at Stennis.[6] Later, space shuttle engines were also tested and certified there by expanding its test capability.

3. NASA Culture (1958—1972)

At the end of the NASA formation process, the agency contained its confederation of cultures from a collection of institutions. NACA with its three research laboratories—Langley, Ames, and Lewis—joined NASA enforcing its laboratory oriented culture. NASA also acquired a significant portion of the Army Ballistic Missile Agency including the German rocket team, which became the Marshal Space Center. It built new field centers—the Johnson Space Center in Houston, for example—to increase its capability toward manned space flight. The Langley's Space Task Group moved there and headed the center which resulted in development of a culture similar to that of NACA. Another field center was the Kennedy Space Center in Florida formed by the German rocket team. NASA also obtained a substantial number of employees from the Naval Research Laboratory and developed the Goddard Space Flight Center for unmanned space flight operations with employees from the Naval Research Laboratory. The Jet propulsion Laboratory of the California Institute of Technology was also attached to NASA. As part of the manned space activity, NASA also took rockets and managers from the Air Force Ballistic Missile Program. Figure 5 displays the NASA Centers in 1961.

[6] See for more information: National Aeronautics and Space Administration, Stennis Space Center, http://www.nasa.gov/centers/stennis/about/history/history.html, accessed October 2007.

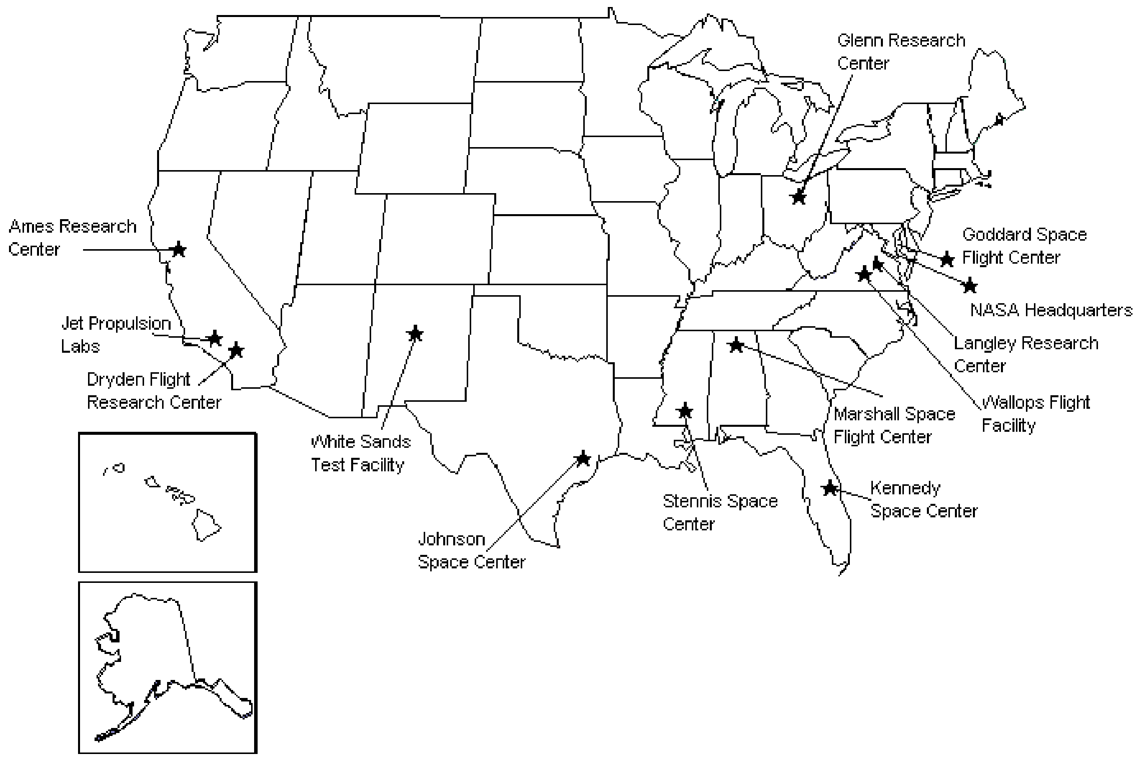

Figure 5. NASA Centers (From: McCurdy (1993))

In sum, each institution, center, and group constituted key aspects of NASA's emerging culture leading eventually to a distinct NASA culture. Research and testing, in-house technical capability, hands-on experience, seeing risk and failures as part of normal space exploration, a frontier mentality and hiring exceptional people were distinctive cultural variables during NASA's first period (1958–1972).

a. Research and Testing

NACA, which had a long history since 1915, was the premier institution for aeronautical research in the United States before joining NASA. As indicated earlier, its three research laboratories were relatively small organizations and isolated from the major administrative operations of the federal government. One of the NASA engineers who started his work at NACA described the environment of laboratories as "more like working at a university

campus doing research." The laboratory products were scientific and always one in-house. NACA researchers produced more than 16,000 technical papers before joining NASA. At that time, the only aeronautical research sources used in universities were NACA papers.

Research was the nature of the tasks in NACA; consequently, NACA's small laboratories were completely research-oriented. However, in the newly formed NASA space agency, tasks and missions began to change. Space flight supplanted aeronautical research as the primary task. NASA would construct rockets, spacecrafts, and satellites to reach the moon. Although the job changed, NASA's basic approach or method to solving problems and completing tasks stayed the same. One year after NASA was established, management prepared a long-range plan stating: "During the coming ten years, NASA activities will involve extensive programs of engineering development and scientific research" (quoted by McCurdy, 1993, p. 29).

The core of NASA was the old NACA research centers, and NASA space flight managers prepared for their tasks through extensive research and testing. The unknowns of the space environment created this need for extensive research and testing, but the care, particularly attention to safety, with which NASA employees did this work allowed the agency to feel confident about its activities. As an example of this careful attitude toward research and testing, John Glenn, a NASA astronaut, spent 40 hours in formal briefings on the special features of Friendship 7, and more than 100 hours in the actual spacecraft during tests prior to his flight. In addition, he and his back-up pilot spent about 90 hours in the procedures trainer during which complete mission simulations were practiced (Webb, 1962, p. 5). Glenn commented that his first flight in space "was much less novel than might be supposed, because I had already experienced it a hundred times on the ground" (Webb, 1962, p. 5). NASA officials conducted 17 unmanned flight tests of the Mercury capsule to see how it would work before John Glenn orbited the earth. One manager said "if we had needed more, we

would have flown more times" (McCurdy, 1993, p. 30). Regardless of the cost incurred by testing, learning, accumulation of knowledge, and safety were highly valued in NASA culture in the first period (1958–1972).

The ABMA, the second biggest group in NASA, had approaches similar to NACA in their "way of doing" things. They did extensive research and testing to discover how rocket hardware worked. The German rocket team, the nucleus of the ABMA, did detailed, extensive testing and, whenever something broke, they redesigned it. Testing was highly valuable to employees because they had the opportunity to see what was working, what was not, and why. As part of this "testing" culture, the German rocket team accepted some failures as "successful failures" and some as "complete failures" according to their own testing philosophy. If they experienced a failure in testing, and if it taught them something new, then they classified it as a successful failure. If they learned nothing from the failure, this was then a complete failure (Amy, 1990; McCurdy, 1993).

According to McCurdy (1993), the success in a research organization depends upon developing sophisticated testing and verification skills, and procedures. In other words, scientists and researchers must test their findings to continue to the next step in developing and accumulating skills. The following comment well articulates NASA's focus on testing to carry out their tasks toward the end of the first period: "These had been the first steps in the process—a slow and methodical progression which increases the times in orbit and the amounts of data returned from the flights. The duplicating flights were planned and made to assure that more than luck or coincidence was involved" (America in Space, 1968, p. 24).

Even when NASA began to contract out most of the work in 1962, its belief in extensive testing did not change. NASA employees did further testing even after receiving the testing and verification documents of manufacturers. Testing was first done on prototypes. When the actual production began, each individual component was tested again. Later, the complete product was tested

in the contractor's manufacturing facilities. As an example, in the Apollo project, each part was tested separately, each subset of parts was tested, and the complete project was tested. Testing was elaborate and nothing was left to chance.

b. In-house Technical Capability

As stated earlier, NASA consisted of NACA, a large portion of ABMA, and a sizable number of Navy personnel from the Naval Research Laboratory. The trust and desire for in-house capability came from these pre-existing organizations, which possessed substantial in-house technical capability to complete their small-size projects. More than 80 percent of NASA's technical core, namely engineers and scientists, were from these organizations in the first period (1958—1972). They had their own in-house facilities to work on their research and projects before joining NASA (Launius, 1995). For example, The Langley Research Center was famous for its model-building shops. The Naval Research Laboratory (NRL) was an in-house government facility mostly working on developing satellites for the Navy and Department of Defense. The Vanguard project—America's first satellite program—was also carried out by NRL between 1955 and 1959 and later was transferred to NASA. In addition, the first intelligence satellite of the nation, Grab I, was designed and built by NRL. The German rocket team, working first at the Redstone Arsenal and then the Marshall Space Center, was developing rocket hardware. They built the first Redstone rockets, which was used to launch the first American astronaut on a suborbital trajectory. In fact, the first 17 rockets were built at government facilities.

The von Braun rocket team with considerable in-house capability also built the first eight Saturn I stages at the Huntsville facility. Even after work was contracted out, this team developed a general rule that 10 percent of the money spent on rocket development should be spent in-house to retain in-house

capability. Similarly, The Goddard Space Center, although it relied much on contractors for satellite development, always tried to produce at least one small satellite in their workshop.

The belief that NASA must have in-house capability was for the following reasons: First, they thought in-house capability provided a training environment in which scientists and engineers can keep their hands on the jobs and sharpen their skills. Second, in-house capability can provide project flexibility by creating institutional memories. In case of a failure, available technical skills at hand could efficiently correct problems. Otherwise, looking for solutions outside the agency might delay projects since project members became scattered in the industry environment after the work was completed. Third, this capability could offer challenging tasks to talented engineers and scientists enabling them to be innovative, thereby reducing turnover by maintaining a satisfying job environment. Fourth, in-house capability was deemed important in monitoring and directing contractors' work. Without it, project initiatives in terms of design, cost and schedule would be left to contractors. Finally, in-house capability was believed to protect and guarantee the agency's future. NASA employees believed that their research and technical activities were the reasons the space agency existed. Consequently, they did not want to contract out all of its research and technical work. If it did that, the agency would lose its core capability and become no more than a bookkeeping organization.

This emphasis on technical competence, evaluation of work based solely on technical merits, and an in-house research environment comprised key aspects of NASA's culture during its first period (1958–1972).

c. Hands-on Experience

The prior technical culture of NACA centers and the ABMA also placed high value on hands-on experience. The hands-on experience culture, like in-house capability, flourished in relatively small projects, which was the primary type of project size NACA's centers engaged in. One of the leading

NASA engineers, formerly a NACA engineer, described the size and number of projects in NACA as: “The thing about the NACA was that there was a great number of very small projects current at any one time” (cited in McCurdy, 1993, p. 43). As previously stated, in-house capability provided opportunity for hands-on experience, and engineers and scientists had flexibility regarding what they wanted to do and how they were going to do their jobs, tasks or research projects with allotted funding (McCurdy, 1993). This flexibility seemed to encourage development of extensive technical skills, including first-hand experience. For example, NASA’s own astronauts flew the spacecrafts, and NASA employees sat at consoles at Mission Control and controlled and directed the flights.

Hands-on experience, according to NASA employees, was also essential to monitor the work of contractors (McCurdy, 1993). NASA employees evidently believed that relying on their own experiences allowed them to effectively monitor the technical detail of contractors’ work, including requiring contractors do necessary project corrections according to the design, development and cost planned by NASA engineers. As an indication of the preservation of hands-on experience, six of twelve explorer satellites were built by the Goddard Space Center employees in their own facilities (McCurdy, 1993). Also, hands-on experiences of NASA employees helped the agency make a quick start on the lunar landing mission. For example, the engineers and scientist played a key role by providing technical knowledge to Apollo Project managers, enabling the managers to lead the contractors involved in the project efficiently.

d. Risk and Failures as Part of Space Exploration

NASA managers did not anticipate progress in space exploration without initial risk and failures. In addition, no one including the President, Congress and the nation expected NASA’s first steps in space to be completely error-free (Amy, 1990). The reason of anticipated risk and failures was that the space activities and environment were full of unknowns. Risk comes in many forms in human space travel, e.g., spacecraft engines can malfunction

unexpectedly. Electrical malfunctions or loss of spacecraft connectivity can happen possibly resulting in casualties. The Apollo program leader pointed out how NASA employees treated risks in space exploration: “Anybody that gets on the end of a flaming rocket and does not recognize the risks and dangers associated with it, does not understand the problem. We were well aware of the risks we were taking. On the other hand—and I emphasize this very, very carefully—we would never fly a manned vehicle if we knew something wrong with it until we fixed it. That is not to say that there were not some unknowns. That is not to say that we did not recognize the risk involved in the operation every damn time we went to pad.” And he concluded that “Recognition of risk is what made us as good as we were” (McCurdy, 1993, p. 62). Knowledge of the space environment was not mature. In other words, NASA did not have enough knowledge about what they were doing to avoid taking risks. NASA employees thought that even if they did everything they could to assure flight safety, they could not be completely sure about what would happen when they launched a spacecraft into orbit. A top manned space flight official clarified that “we were going to kill the astronauts in our Gemini flights by allowing them to stay up there more than one day—and going to Congress with a whole set of letters saying that” (McCurdy, 1993, p. 63). Therefore, they accepted the possibility of even human causalities during space flights and training activities.

Also, NACA’s and NASA’s prior experiences taught them failures even including human life were a necessary part of the process of space research in which lessons were learned, leading ultimately to success. For example, between 1948 and 1957, NACA and NASA lost three pilots in testing aircrafts. One of the leaders of the Apollo program said: “you did not learn except by failures. Now, you did not set out to kill people and you did not ever fly a machine in a flight regime where you did not have a reasonably good understanding of what the flight characteristics were going to be or the environment that you were going to fly in. But—and this is a very callous statement—we of the flight test business were acquainted with death” (McCurdy,

1993, p. 62). However, especially NASA's manned flights were broadcasted in various media channels and were highly publicized (Amy, 1990). Consequently, tolerance for loss of life was different for test pilots than for astronauts due to the public eye constantly being on the astronauts. The space agency was risk-averse in order to not loose astronauts' life in flights. Ultimately, the NASA astronauts who landed on the moon were elevated to "hero" status by the public, and were remembered as the most known figures of the space activities.

NASA executives did not permit the bureaucratic tendency to avoid failure by denying that it could happen. Only by accepting the reality of failure could the organization deal effectively with it. In a similar approach, Webb (1962) stated that "safety culture" respected risk and failures only if all necessary precautions were taken: "We strive to maintain 100 percent reliability in manned space flight and to remove every danger and uncertainty that we can from this ever-hazardous undertaking" (p. 5).

McCurdy (1993) pointed out that "the normalization of risk, the acceptance of risk, and the anticipation of trouble led to an atmosphere in which things could be discussed openly. NASA's ability to handle risk required open discussion in which mid-level managers and engineers felt unrestrained in voicing warnings and dissents" (p. 65). This atmosphere, in fact, came from the technical culture of prior organizations. Everybody could express their opinion up and down the communication system. In NASA's culture, open communication was paramount, and failures were seen as part of making progress in space activity. For example, one of the agency's top spacecraft engineers described the communication environment of NASA, which had its roots in the technical cultures of NASA's predecessor organizations, as: "There was a great deal of democracy in the management. Everybody…was free to state their feelings. No one was treated any different if he objected to what management would think than if he praised what management would think. Management did not look for praise. They looked for anybody with good advice" (McCurdy, 1993, p. 65). To weigh all options, managers of NASA relied on dissenting views. Employees felt

unrestrained in voicing warnings and dissent. Thus, NASA's ability to handle risk and prevent unnecessary failures appeared to be optimized through an open communication environment.

In sum, NASA's culture saw failure as part of the space process, while at the same time trying to eliminate failures by creating an open-communication environment. This attitude helped NASA to accumulate knowledge step by step, and to eventually achieve success.

e. Frontier Mentality

A frontier mentality is meant to describe an essential aspect of NASA's technical culture. Frontier mentality refers to the desire to embark on new challenges, to make new discoveries, to try something harder each time, to invent and build new things, and to test and investigate new things. In short, it is about expanding technical and scientific knowledge and skills to purposefully seek and solve new problems and challenges. Engineers and scientists before NASA and during the first period of NASA (1958—1972) had ample opportunities to keep the idea of exploring new frontiers alive.

The knowledge and the skills needed to conduct space exploration were sorely lacking before NASA was established. This limited knowledge about space flight helped employees to bring this frontier mentality to NASA. With NASA, various projects such as Gemini, Mercury, and Apollo allowed engineers and scientists to further cultivate this frontier mentality, since each project challenged them by presenting new difficulties. Since space exploration is full of new opportunities, the frontier mentality in NASA's culture was always kept alive during the first period of NASA (1958–1972).

f. Hiring Exceptional People

NASA believed that the only way to accomplish the most challenging task they had ever faced was to have an exceptional work force. The prior organizations included in NASA such as NACA and ABMA had already

started their space research activities with talented engineers and scientists. NACA was able to attract personnel with exceptional skills by offering them the freedom to do interesting research.

Freedom was important for skillful researchers in that it enabled them to better sharpen their knowledge and experience by minimizing constraints. Also, the fame of NACA and its laboratories as a research-oriented institution in the United States helped them to attract employees with the best skills. The von Braun team and the 200 engineers who moved to the Goddard Space Centers had the finest engineering skills in the United States (McCurdy, 1993).

NASA also did not change this tradition and adopted the culture of hiring employees with the best available skills. Also, the challenge and mystery of the historical moon landing mandate motivated talented people from universities, industry, and government to join NASA. These talented people thought they could help make history and thus would be able to write their names in people's memory by being a part of a project that put a man on the moon (McCurdy, 1993; Launius, 1995).

Among the other factors that enabled NASA to recruit employees with exceptional skills was the elimination of constraints put on hiring managers by the central personnel agency. NASA was allowed to create around 700 positions, which were excluded from the ordinary personnel management bureaucracies, and had the flexibility to pay competitive salaries to the employees in these positions (Levine, 1982). In addition, NASA recruited large numbers of people to carry out the challenging moon landing task and allowed these people to move between NASA and private industries and universities whenever they wanted, which was the opposite of other governmental agencies' practices. This flexibility created a young, ambitious, and skillful workforce for the agency. As a result, the turnover rate during the 1960s was more than two times that of the 1970s, and the average age of the employees was 38 in the mid-1960's, which was the lowest average in the agency's history (McCurdy, 1993).

Young people brought new ideas, new capabilities, and new ways of working to NASA. They were also not influenced by agency politics and past failures. Most importantly, they were ambitious. They worked long hours which strengthened the hard-work culture of the agency. Furthermore, the exceptional performance of the young people contributed to the can-do attitude of the agency.

During the first period (1958–1972) all of the above-mentioned cultural traits of NASA such as extensive research and testing, in-house technical capability, hands-on experience, seeing risk and failures as part of space exploration, hiring exceptional employees, and the frontier mentality were transferred from prior organizations. These cultural traits played an important role in the performance of the organization and were developed and adopted over the years after successful completion of research projects and technical jobs. However, this did not mean that when these cultural traits were passed on to NASA they guaranteed NASA's success. It's important to look at the alignment of these cultural traits with NASA tasks and with the people, resources, and its structure to see potential performance impacts. If the culture and these crucial organizational components were incongruent, then dysfunctional effects can result (O'Reilly & Tushman, 1997).

B. ALIGNMENT OF NASA CULTURE WITH TASK, PEOPLE, RESOURCES, AND STRUCTURE

1. Task

In the formation and early growth of NASA, U.S. Presidents mission taskings appeared straightforward. In the first two and a half years, during the Eisenhower administration, NASA was simply not capable of manned space flight. Thus, the only manned space flight mission for which the agency received authorization was the relatively small Project Mercury, intended to sustain a single astronaut in low Earth orbit for one day (McCurdy, 1993). President Eisenhower's space program placed great emphasis on satellite technology and

deemphasized the role of humans in space (Lauinus, 1995). He continually disapproved any manned space flight program that went beyond the single-seat Mercury capsule, which he evidently believed was a precursor for determining human space travel.

President Eisenhower indicated that the value the country could get from scientific investigations conducted on Earth outweighed the value that could be obtained from discoveries in space. According to President Eisenhower, the U. S. was leading the scientific field, while the Soviet Union led the engineering field; consequently, there was no need for a race to explore space. He clearly stated these points after leaving the White House by saying, “Why the great hurry to get to the moon and the planets? We have already demonstrated that in everything except the power of our booster rockets we are leading the work in scientific explorations. From here on, I think we should proceed in an orderly, scientific way, building one accomplishment on another, rather than engaging in a mad effort to win a stunt race” (cited in Launius, 1995, p. 37). But, there was a heated debate in Washington regarding the direction of NASA. As a result, the long-range direction of NASA’s space flight program remained uncertain until 1961.

With the inauguration of John F. Kennedy, a new and bright era began for NASA. President Kennedy was in favor of an assertive, large-scale, and far-reaching manned space program. He provided an extremely challenging goal for NASA by delivering an inspirational visionary statement: “I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth,” before a joint session of Congress on May 25, 1961.[7]

President Kennedy evidently believed that science and technology could solve almost any societal problem, i.e., a stated trust in the power of science and technology. That belief helped spark his 1961 decision to go to the moon (Launius, 1995). Another reason for the moon mission was created by the Cold

[7] National Aeronautics and Space Administration, NASA History Office, http://history.nasa.gov/moondec.html accessed October 2007.

War atmosphere in which the space race became a primary metaphor for superpower status. The Soviet Union had already launched the Sputnik I satellite, and many U.S. policy makers thought the Russians might use space for military purposes. James Killian (1977) described the effect of Sputnik I launching: “Sputnik I created a crisis of confidence that swept the country like a windblown forest fire. Overnight there developed a widespread belief that the country lay at the mercy of the Russian military machine and that our government and its military arm had abruptly lost the power to defend the homeland itself, much less to maintain U.S prestige and leadership in the international arena” (p. 7).

Public attention also began to focus on the relationship between Cold War dominance and the space race. “Control of space means control of the world,” said Senate majority leader Lyndon Johnson to his colleagues in 1958 (Launius, 1995, p. 41). According to Werner von Braun, the head of the army rocket team, “there will also be another possible use for the space station. It can be converted into a terribly effective atomic bomb carrier” (Lauinus, 1995, p. 43).

With the mission of dispatching Americans to the moon, NASA developed the Apollo project. According to a NASA document, “Apollo provided an easily identifiable target as a focus for the energies of hundreds of thousands of scientists, engineers, technicians, craftsmen, and administrators in both government and private industry who were engaged in the program” (This is NASA, 1969, p. 6). James Webb (1962), the second administrator of NASA, compactly stated NASA’s goal for the 1960s when he said, “We are moving toward achievement of our national goal of mastering the space environment and attaining, as the President urged, ‘a position second to none’” (p. 3). America, as the President urged, would be the leading nation in space and would establish its superiority in science and technology through space exploration.

To accomplish this task, NASA began to develop further technical, scientific and engineering skills and knowledge. Step by step, NASA mobilized its resources toward moon landing. According to NASA, “tracing the road to Apollo

could be like tracing the steps of man's scientific and engineering achievements since he discovered fire and invented the wheel" (America in Space, 1968, p. 5). Webb emphasized the challenge of space exploration by indicating its requirements as "the accumulation of knowledge, skill, and experience [that] must precede ultimate achievement in any undertaking, with the failures as well as successes providing the foundation for eventual victory" (Webb, 1962, p. 10).

The cooperation and interaction among centers appeared to improve with this new, complex, and interrelated task. In the Apollo project, "a number of co-equal centers were responsible for various program segments. Only headquarters had the overview and took upon itself the responsibility for coordination" (Chandeler & Sayes, 1971, p. 177). There were also a multitude of inter-center "panels" and interface "boards" that brought together all the parties interested in a specific project problem. Also, for the Apollo project, a central Apollo Program Management Office was established in Washington to control and coordinate the works of field centers. This management office charged the Marshal Space Center with developing the launch vehicles; made the Johnson Spacecraft Center responsible for the development of the spacecraft, astronauts training, and the control of the mission in progress; and gave the Kennedy Space Center responsibility for assembling, checking out and launching the spacecraft.

Apollo's task or moon landing required high engineering and scientific skills to design long-range rockets, powerful engines, sophisticated communication systems, command modules, and so forth. As indicated earlier, NASA had a technical and research culture which it adopted from the parts of prior organizations that were integrated into NASA. Furthermore, the agency's frontier culture encouraged employees to do things that had not been done before. The culture of engineers is to "invent and build, make it work, watch it work, and then go up and invent, build and watch something else work" (McCurdy, 1993, p. 73). Apollo's new challenges reportedly kept people alert and prevented complacency. In a culture that accepts risk and failure, people were

encouraged to bring forward problems and errors. Such an attitude seemed highly conducive for employees to do outstanding work, and that attitude was an integration of NASA’s different occupational cultures.

The Apollo program was large and complex which required the bulk of the work to be contracted out. Hence, it required high-quality project management skills which were the weakest aspect of NASA’s culture at that time (Kloman, 1985) since the culture inherited from prior organizations highly valued in-house capability. The Air Force managers NASA brought in to serve as program managers commented that “NASA had a considerable technical depth, but almost no program management experience” to work with industry on large programs (McCurdy, 1993, p. 92).

Much of the work of the Gemini and Apollo projects were completed with substantial contractor assistance. By bringing experienced, highly skilled contracting and program management Air Force personnel to NASA’s Apollo program management, the agency strengthened this weakness which may have been crucial for putting a man on the moon. NASA’s technical culture appeared to take the initiative in contracting, in that it did not contract out all the Apollo work. It kept a sufficient amount of work inside so employees could have hands-on experience and the agency could maintain in-house capability. Therefore, the hands-on experience and in-house employee capability appeared instrumental in controlling contracted-out technical details and design decisions. Engineers and scientists provided program managers with the array of technical information needed for effective project management.

In sum, the Apollo project needed many contractors and needed them to be well-managed, such that contractors and NASA employees could jointly design and develop sophisticated and capable spacecraft systems under time pressures. NASA’s technical and research culture from prior organizations appeared to develop the necessary program management attributes, perhaps driven by experienced Air force managers. This fit or alignment between technical/research capabilities and program management capabilities is key to

understanding the topic of this study. Variables interacted in such a way as to create a dominant organizational culture, which successfully accomplished the entire moon landing challenge within the envisioned decade.

2. People

As designers and builders of organizations for thousands of years, people can arguably be described as the most important variable. The general premise is that the right strategy and the right product can perform only with capable people working towards a common purpose. The variable, which may therefore have the greatest impact on performance, is a belief system – a culture – that guides human decision making for thousands of organizational employees. The closer the fit of interacting components, the more focused and diligent the accompanying culture.. Obviously, senior leaders and managers have some discretion over who is hired, and who is promoted or let go. If an organization continues to make decisions, which strengthen its cultural attributes, then the probability of high performance increases. One secret to NASA's exceptional success in the first period (1958–1972) was its "exceptional" people (Launius, 1995; Levine, 1982; McCurdy, 1993).

NASA had a culture of seriously hiring qualified and motivated employees. To expand upon the notion that NASA was really a combination or infusing of four prior organizations—NACA, ABMA, JPL and NRL. The predecessor organizations themselves were already focused on recruiting outstanding people. One NASA official commented about the people of NACA: "The NACA basically hired the cream of the crop from colleges—the intellectuals—because they had a reputation for that" (McCurdy, 1993, p. 51). NACA mostly employed engineers and scientists from the best universities such as the University of California, Stanford, and the University of Washington.

The Naval Research Laboratory highly skilled employees comprised the nucleus of the Goddard Space Centers. One of the officials in this center described the level of knowledge of employees as: "…I did not realize it when I

started out, but found out very quickly that I had got about 50 percent of the people of the United States that knew everything about satellites" (McCurdy, 1993, p. 52). Similarly, the ABMA with its rocket team had the best talent.

NASA had a limited knowledge and experience about the space environment in 1958, and now it was directly competing with the Soviet Union superpower. The launching of Russia's Sputnik and the goal of lunar landing before 1970 created in NASA scientists and employees a tsunami of creative and competitive tension. "From the outset, space administration heads [NASA management] determined that the agency must build and maintain an exceptionally strong technical competence within its own laboratories" (Seipert, 1962, p. 60). In other words, the performance of the American Space Program was based on the view that NASA could overcome the difficulties of space exploration with a work force composed of professional engineers and scientists. This was one of the most persistent beliefs in the early NASA culture and remained so during the first period (1958–1972).

NASA could hire the most talented people from universities, private industry and other parts of the government for the following reasons: First, the challenge of the work motivated people to join the agency. The work of developing an airplane was attractive and challenging during the time of NACA. Similarly, the task of reaching the moon before 1970 was also a visionary yet reachable challenge for NASA employees.

Manned Space Fight consisted of Mercury, Gemini and Apollo projects in the 1960s. Completion of the Mercury and Gemini projects and the initial stages of the Apollo project positioned NASA to be more capable of landing a man on the moon by the end of the decade. Certainly, each project created new challenges and difficulties, which appeared to act as an even greater motivational stimulus for the scientists and engineers involved.

It is reasonable to offer that the challenges and successes of the moon landing task could have only been accomplished through a committed and

competent work force. NASA attracted and hired skillful engineers and scientists through its technical culture in which engineers and scientists felt they could be both productive and innovative. The culture of the agency allowed employees to enrich their skills, work ambitiously, and to learn from their mistakes. To put it another way, a strong technical core of employees reflected NASA's dominant culture. Furthermore, ample hands-on experience, a focus on research and testing, and a frontier attitude contributed to an organizational climate where people had the tools, ability and motivation to excel in their work. Recall that this culture appeared to normalize risk, and to work with, and not against mistakes and failures, all in the context of an open-communication environment. Evidently, engineers were allowed to be engineers, including a built-in reliance on quantifiable data.

Some say the space race was very much a part of the Cold War. People who wanted to make a contribution to their country saw NASA as America doing what it did best – accomplishing big, bold projects, i.e., winning WWII, building the Suez canal and a national highway system, and surpassing the Soviet Union and attaining the moon in one stroke. Of course, the ability to pay competitive salaries to top scientists and engineers helped. NASA did experience early difficulties obtaining enough specialists to carry out such an innovative, complex and demanding task.

President Kennedy passed the Federal Salary Reform Act in 1962 providing government agencies the ability to pay their employees comparable salaries with the private sector. This act provided NASA the leverage it needed to compete effectively in the bid for talent, and appeared to once again provide a fit of variables needed to ensure resulting performance, i.e., qualified people fitting the knowledge requirements of successful space travel. Rossiter (1992) indicated that the act was approved specifically to enable NASA to quickly and fully obtain the crucial component of a large, complex and highly qualified workforce. Finally, as mentioned earlier, the rapid expansion of the space program with the moon landing task and the relative ease of securing needed professionals contributed

to the “can-do” attitude descriptive of NASA’s overall culture. Seipert (1962) demonstrated this point when he said, “NASA’s technical and managerial staffs have developed an amazing stamina for long hours of work under great pressure” (p. 69). NASA executives often expressed pride in their people. The administrator, Webb (1968), showed his belief and confidence when he said, “NASA has the strongest team that it has ever had” (p. 8). The “America in Space” document agreed with Webb and amplified this point: “This agency brings the best technical minds in the world together to perform spectacular feats” (America in Space, 1968, p. 23).

Also relevant was a positive virtuous cycle. Hiring thousands of competitive people with strong, ambitious drive makes any organization appear stronger, thereby attracting even more highly qualified and exceptional people. As in the Southwest Airline example in Chapter II, NASA also appeared to focus steadfastly on recruiting and selecting people which best fit its continually productive culture. The government authorized the agency to choose its employees through a special exam, which was for NASA’s use alone (Levine, 1982). What made the examination unique was that the applicant, in addition to the required educational background, had to demonstrate “understanding of research and development organizations and their specialized problems, organizational structures, functions, operations, and characteristics” (Levine, 1982, p. 117). This unique testing procedure, combined with the above-mentioned factors, gave NASA considerable control over hiring decisions.

Clearly, one of the strongest components of NASA during the first period (1958—1972) was its workforce. This workforce and the processes used to ensure a fit and strengthening of desired cultural attributes complemented and defined NASA’s cultural core. This alignment of people, task, processes and culture epitomizes the central theme of this study, that the interrelationships and fit of the variables determines performance.

3. Resources

The external environment has constraints and opportunities for organizations that depend on the external environment for resources. Changes in environmental conditions increase or limit the capability of organizations to obtain resources. Favorable changes in the environment are opportunities which affect culture positively. Unfavorable changes are constraints and will affect culture negatively. Organizations will then be forced by pressures to adapt as a result of changes in the environment. This adaptation also includes cultural change (Davis, 1982; Meek, 1988). Also, in Schein's definition of organizational culture (1990) in chapter 1, organizational culture is a tool used to cope with the external environment. His definition refers to external forces such as technological, physical, and cultural environment which have impact on culture. Schein (2004) further explained that "the environment initially determines the possibilities, options, and constraints for a group, and thus forces a group to specify its primary task or function if it is to survive at all. The environment thus initially influences the formation of the culture, but once culture is present in the sense of shared assumptions, those assumptions, in turn, influence what will be perceived and defined as the environment" (p. 51).

Specifically, NASA's primary resources included a sufficient budget, wide-ranging facilities and technical equipment, industry involvement and people. The psychological support of the nation can also be included in the resource category because the agenda of the President and Congress, who funded NASA, are partly determined by the nation's interest. As an example, when the nation gave great support to the agency in the 1960s, the funds NASA received were much greater than the funds it received in the 1970s. When the nation turned its attention after the moon landing to domestic problems such as deteriorating economic conditions and the effects of the Vietnam War, the interest of the President and Congress shifted from NASA to rebuilding economic conditions and ending the Vietnam War (Amy, 1990). Although there are four parts to the

resource category—financial, industry, people, facilities and equipment, the focus of this discussion is on financial and industry resources, because, people, facilities and equipment were discussed earlier in the chapter.

NASA as a government organization was impacted directly by external environmental forces including the role of industry. NASA was extremely dependent on industry because contracting had become a primary tool for accomplishing its complex tasks and objectives. In sum, NASA was performing most of its work through contracts. For example, around 90 percent of appropriations of NASA in fiscal year 1963 were spent on contracts. This rate remained roughly the same throughout its first era, 1958–1972 (NASA—Industry Conference, 1963). To spend the money efficiently and manage the projects successfully, each center within NASA was given the authority to award contracts for the project assigned to it, subject to approval by NASA headquarters. For example, the Marshal Space Center contracted with the Boeing Company, Space Division of North American Aviation, Inc. and Douglas Aircraft Company for engines and the stages of the Saturn space vehicle. The Jet Propulsion Laboratory was operated for NASA by the California Institute of Technology under a cost-type contract, and it too did a substantial amount of contracting.

The culture of NASA, however, placed high value on in-house capability since extensive contracting was not part of the technical culture that NASA inherited from the prior organizations. Although NASA originally valued in-house capabilities, resources were constrained, time was limited, and tasks and objectives were large and complex. Therefore, it had to outsource large parts of projects. To avoid cultural conflict between in-house work and contracting out, the agency, as mentioned earlier, kept a sufficient amount of work in-house to allow engineers and scientists at least conceptually to monitor and to some extent control contractors' work.

The work kept inside the agency left plenty of room for in-house work traditions. For example, although NASA centers contracted out a substantial amount of construction work, much of the construction work at Cape Canaveral,

the Mississippi test site, and the Manned Spacecraft Center at Houston was being done by NASA's engineers (NASA—Industry Conference, 1963). Thus, the culture aligned itself by keeping sufficient amount of work in-house and by only contracting out the work its people were unable to perform. This balance between in-house and contract work enabled NASA to maintain its in-house capability cultural component.

In addition, NASA was hiring talented employees from private companies, universities and other government organizations. NASA could compete with private industry for badly needed "human resources" because of its culture. As stated earlier, NASA was an "engineer-in-charge" organization which was providing employees hands-on experience, challenging tasks, tolerance for mistakes and learning in an open-communication environment. NACA employed 8,000 employees when dissolved in 1958. NASA's in-house employment peaked at about 36,000 in 1967, an increase of 450 percent compared to 1958. During NASA's first year, approximately one third of its 8,000 employees were scientist and engineers. By 1968 nearly half of its 35,000 employees were scientists and engineers. The increase in numbers of employees shows industry and universities had a sufficient amount of scientific and engineering talent and, most importantly, NASA could attract people from these professional labor sources.

The second external force that affected NASA's culture was the President and Congress. As a government agency, NASA's financial resources were allocated by the President and Congress. As stated above, the financial resources NASA received changed from period to period according to Congressional, Presidential and national priorities. During most of the first period (1958–1972) NASA received the financial support it needed to complete its projects. These financial resources enabled NASA to flourish by enabling it to maintain its unique cultural characteristics. In the early years of the first period (1958–1961) during Eisenhower's administration, the space program was kept relatively small and NASA's budget was limited. NASA received $ 369 million in 1959 and $ 485 million in 1960. The amount of budget in these two years was a

little higher than that of NACA (Table 1). However, President Kennedy persuaded the nation and Congress to engage in large-scale space activity, and thereby created an environment of significant support for NASA. Moreover, since NASA's goal of being first in space was presented as a way to prove the superiority of Democracy over Communism, support for the agency continued through Apollo 13's moon landing. One of the administrators of NASA in the early years, T. Keith Glennan, summarized this extraordinary level of support by saying that "congress always wanted to give us more money….Only a blundering fool could go up to the Hill and come back with a result detrimental to the agency" (Launius, 1995, p. 17). Another document, Space Quotes (1969), shows this unprecedented support by noting: "Never before has a free society mobilized its resources with such energy with only peace and pure knowledge as objectives" (p. 3). Figure 6 shows the NASA's budget between 1959 and 1973.

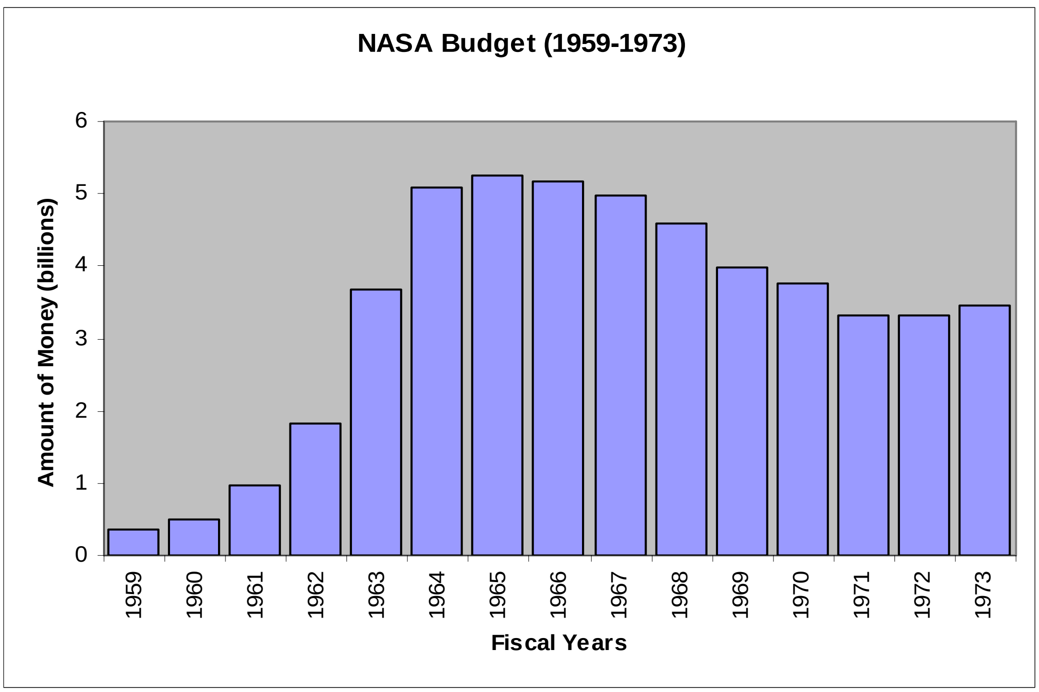

Figure 6. NASA's Budget (1959–1972) (After: National Aeronautics and Space Administration, NASA History Division, http://history.nasa.gov/SP-4012/vo13/table1.2htm, (accessed October 2007)).

NASA's budget increased ten fold, from $500 million to $5.2 billion in the five years between 1960 and 1965. The budget began to decrease after 1965, since NASA completed major Apollo research and development tasks and much of the hardware needed for the lunar mission had already been procured by 1965. Although Congress started cutting the space agency's annual budget,[8] there were no major discrepancies between NASA's requests and the amount of money allocated by Congress in the first period (1958–1972). For example, NASA requested $ 5.26 billion in 1966 and $ 5.19 billion was allocated, i.e., NASA received over 95 percent of its budget requests. This rate was one of the highest among government agencies.

All in all, the agency was allocated sufficient budget to continue its program of scientific and engineering development required to complete the moon mission. With the positive effect of funding, NASA continued to do systematic research, testing, and design resulting in a step by step accumulation of knowledge.

4. Structure

As discussed in Chapter II, culture is a complex topic. Similarly, structure is complex. Although organizational charts are used to show the structure of an organization, it is very hard to say that it is an adequate description of what really takes places inside the organization. Many important power and communication relationships which are in the organizations are not put down on paper. One of the best examples was given by Mintzberg (1979): "A map is invaluable for finding towns and their connecting roads, but it tells nothing about the economic and social relationship of the region" (p. 37).

[8] For more information, see National Aeronautics and Space Administration, NASA History Division, http://history.NASA.gov/SP-4012/vol3/ch1.htm, (accessed October 2007).

Baligh (1994), one of the few researchers studying on structure and culture relationship, hypothesized to find out the alignment between structure and culture that if a culture: (1) values altruism over selfishness (the group more highly than the individual), (2) believes that cooperation is more efficient than competition in achieving group goals, (3) believes that harmony in personal relations is best at getting cooperation, then the organization structure that fits it at a high level has: (a) very high level of participation by all members of the group in making the decision rules for every member, (b) decision rules made by consensus, (c) decision rules that are medium in level of fineness, (d) decision rules that are high in level of comprehensiveness, (e) rewards to each individual based mostly on group performance or its outcome, (f) rewards to each individual based slightly on his performance relative to the decision rules he is given to use (p. 24).

His conclusion is that trying to analyze the fit between an entire culture and an entire organization structure is not conclusive. However, he proposed the analysis be in terms one or a few attributes of culture with one or a few attributes of the structure. For example, the flat structure of universities with chairs and deans as managers having a large span of control and important decision making occurring at the lower levels of the organization, such as faculty members, helps to create or reinforce a culture of autonomy, choice, and career self management.

Keeping above-mentioned points in mind, we will find out which structural configuration NASA had in the first period and analyze the alignment between cultural variables explained earlier and its structure. As already discussed in chapter III, although the relationship between structure and culture is not clear enough to examine, its final impact is on the performance of the agency. Hence, the right criteria to measure the degree of fit should be the performance of NASA which culminated with the moon landing.

The NASA structure changed frequently to enable the agency to maintain flexibility, which was one of the most important aspects of NASA culture, and to adapt to changes in tasks. The complexities of jurisdictions, the network of informal relations, the shifting of functions between offices, and the blurring of the lines of authority caused NASA to reorganize four times—in January 1961, November 1961, November 1963, and May 1968 (Levine, 1982). These reorganizations can also be seen as an effort to create the suitable structure which supports “the way employees do things.”

NASA divided space activities into groups in 1961. This division was unavoidable because early organizations (i.e. Ames, Langley, and Lewis Laboratories) had developed skills in one specific area. Hence, division of labor had to be done when NASA was first established. Accordingly, each center was given a specific task. As mentioned earlier, the manned space flights were given to the Johnson Space Center, the launching task to the Kennedy Space Center, the testing of hardware such as spacecraft to the Stennis Space Center, and the unmanned flights to the Goddard Space Center and the Marshal Space Center. These field centers and the Jet Propulsion Laboratory were considered principally as development centers. The formerly NACA—operated laboratories, namely Langley, Ames, and Lewis, were focused on advanced research and technology studies. These laboratories were thought of as research centers, and they continued to do their same jobs under NASA. Figure 7 shows the simplified organizational chart of NASA.

Office of the Administrator			
Program Offices			
Manned Space Flight	Space Sciences and Applications	Advanced Research and Technology	Tracking and Data Acquisition
Field Centers			
Marshal Space Flight Center	Goddard Space Flight Center	Ames Research Center	
Johnson Space Center	Jet Propulsion Laboratory	Langley Research Center	
Kennedy Space Center		Lewis research Center	
		Flight Research Center	

Figure 7. Simplified Organizational Chart of NASA (From: Chandler & Sayles (1971))

The above division of activities and the centers' geographically isolated locations provided them with flexibility and autonomy even when thousands of new civilian personnel were hired, on-site contractor personnel started work at the centers. Congress appropriated significant financial resources, Congress and the nation had extremely high performance expectations. The autonomy of field centers increased while working on the Gemini and Mercury projects. The division of labor allowed for decentralized decision making. The decisions in each center were made based on the best technical knowledge and judgment. Conflicts were resolved through open discussion. Engineers and scientists were able to voice their views while participating in the decision-making process. In addition, the communication channels were open in both upward and downward directions. In short, engineers and scientists were allowed to control their projects. They decided what to do and how to do it.

The huge autonomy, large span of control and flexibility in project management in the agency sometimes frightened NASA administrators (Levin, 1982). James Webb, the second NASA administrator, worried that the space agency's field centers would "go into business for themselves" (Young, 1986, p. 37-38). Even though he had this fear, it did not happen because NASA reorganized itself for the Apollo project. Although this project was centrally managed, the culture of NASA which valued flexibility, autonomy and expertise in doing work was also prevalent in carrying out the project. The management of NASA located in Washington appointed General Samuel Phillips as the overall Apollo program director and placed him in the central office in Washington. He was given the choice of hiring his own contractors without competitive bidding to perform overall system engineering and integration work. The field centers which had the primary responsibility for the moon landing task reported directly to Phillips (McCurdy, 1993). This restructuring with the result that project autonomy resided with the Apollo program director demonstrates that the flexible, can-do culture of the agency affected the restructuring and implementation of Apollo by energizing management and centers to take every necessary step toward the accomplishment of the mission.

According to Minztberg (1979), aerospace, petrochemicals, think-tank consulting, and film-making organizations should be structured as adhocracies. The common points of all of these organizations are innovations that need to be done in complex ways are typically accomplished by "mutual adjustment through the informal communication and interaction of competent experts" (p. 111). Obviously, NASA constantly needed to innovate to beat the Russians to the moon.

Adhocracy has both operating and administrative forms. The operating adhocracy carries out projects under contract on behalf of its clients. An advertising agency, a think-tank consulting firm, and a manufacturer of engineering prototypes are examples of this type. The administrative adhocracy undertakes projects on its own behalf. The industries in which they operate

require “project structures” that take experts from different specialties and merge them into smoothly functioning innovative teams. Therefore, adhocracy is the structure designed for effective functioning of project teams.

NASA as a space agency was a perfect example of an “administrative adhocracy” in the Apollo era (1962–1972) (Chandler & Sayles, 1971). First, the administrative adhocracy tends to concentrate its attention on fewer projects, which involve more people in interdependent relationships. For example, through the 1960s, NASA focused on the single goal of putting a man on the moon before 1970. NASA’s Apollo project involved most of its personnel for 10 years. When the project ended, the employees working for NASA with contracts became scattered throughout the industry.

Second, adhocracy is a fluid structure in which power, coordination and control are constantly shifting. It relies on trained and specialized experts to get the bulk of its work done. Experts work together to create new knowledge and complex technologies, e.g., a lunar lander. Hence, for coordination adhocracy relies on mutual adjustment, which it encourages by the use of liaison devices—integrating managers, task forces, and matrix structure. Experts are dispersed throughout the structure according to the decisions they make. So, the power is distributed unevenly. It flows to wherever the expertise is needed for a particular decision. For example, according to Chandler & Sayles (1971) “While there may be a number of permanent operations in such projects, much of the work is temporary. People get shifted around and plans get changed in an environment quite different from the tiresome monotony bemoaned by so many in traditional institutions. Projects, task forces, and temporary “teams” also mean that individuals have multiple organizational “homes.” A scientist may be a part of a university, responsible for the design and testing of an experiment to be flown by a NASA spacecraft, serving as a consultant to an industrial contractor that builds equipment for the agency, and a member of an advisory board that helps shape future science policy for NASA and other governmental agencies (p. 6).

Functional, integrating, and project managers play important roles in an adhocracy. Their roles, though, are different from the roles of managers in other structures. They do not directly supervise the members of the team. They behave more like other team members, with their primary task being to link different teams necessary to accomplish the work. The primary role of top management in an adhocracy is that of a liaison with external stakeholders. Chandler and Sayes (1971) noted that NASA's top management had the role maintaining "external relations with various units of the Executive Branch, with Congress, and with key public groups representing private universities, business, the scientific community, and various international interests" (p. 173).

In a project structure, power is based on expertise, and organizational strategy is everybody's work, not just that of the top managers. In other words, strategy is developed by the involvement of multiple levels of experts (Mintzberg, 1979). For example, Chandler and Sayles (1971) noted during NASA's Apollo project period that "…while it is clear who has the authority to make, and who announces, the final decision (the top administrator of NASA), it is much more difficult to say who, in fact, makes the decision. It is the product of a complex process of interaction and confrontation in which technical, administrative and broader political criteria are applied and in which both technical and managerial personnel participate…. Decision-making is a process in which various organizational levels and interest groups compete for position in a sequence and to make their voice the strongest" (pp. 174–176).

According to Toffler (1970), adhocracies "change their internal shape with frequency—and sometimes harshness—that makes the head swim. Titles change from week to week. Jobs are transformed. Responsibilities shift. Vast organizational structures are taken apart, bolted together again in new forms, then rearranged again. Departments and divisions spring up overnight only to vanish in another, and yet another reorganization" (p. 128). For example, the Manned Space Flight Center of NASA changed its structure 17 times in the first eight years of its existence (Litzinger, Mayrinac & Wagle, 1971, p. 7). The reason

for frequent changes in the structure of NASA's Manned Space Flight is that it lacked the advantages of those that do repetitive work. Since project work is usually "being the first done for the first time…precedents and policies are somewhat irrelevant" and "it is difficult to draw neat jurisdictional lines" (Chandler & Sayles, 1971, p. 202).

Finally, in an adhocracy structure, information and decision processes flow flexibly and informally, wherever they must to promote innovation. And, innovation requires creating new knowledge or skills by enabling people with novel, fresh perspectives to generate ideas or by integrating information from ever-changing groupings of people. Relying on the standardized skills of experts rarely leads to innovation. For example, "An electrical specialist can spot a mechanical problem, perhaps in part because he does not know the conventional wisdom, and a bright engineer working in an apparently unrelated field can come up with a solution to a problem that has been frustrating the functional specialists" (Mintzberg, 1979, p. 434). One NASA executive commented about the information flow in NASA: "to be on the safe side, NASA may err in over communicating upward, laterally, and downward. It engulfs anyone who can conceivably influence or implement the decision. It establishes various management councils composed of co-equal associates to share progress and problems on a frequent basis. In an unending effort to exchange information in real time, it uses telephone, hot lines, executive aircraft, data fax, long distance conference hook-ups by voice and data display and computer data transmissions" (Chandler & Sayles, 1971, p. 20).

The previous points clearly indicated that NASA structured itself as an adhocracy. Obviously putting a man on the moon proved to be a very complex task, requiring the coordinated knowledge and expertise of a multitude of society's most talented scientists and engineers. Moreover, the task was unpredictable—having never been tried before—and rendered more dynamic by the fact that it was carried out as a race with the Russians. The agency focused its single goal of moon landing and mobilized all of its resources. NASA's cultural

variables thrived within this adhocracy structure. The frontier culture of NASA was a necessary part of innovation essential to space exploration. The main emphasis of the adhocracy structure which makes it different from other structures is the innovation. This fit kept the employees of the agency motivated which, in turn, supported trying and achieving new things. The challenges and difficulties of space exploration were overcome by the substantial information sharing and decentralized decision-making that the adhocracy valued. This structure also provided engineers and scientists with sufficient flexibility to use their expertise to solve complex problems of space flights they encountered while working on their projects. Engineers and scientists to improve their technical knowledge which is the source of their expertise had to place more value on hands-on experiences and in-house technical capability. The inclusion of multiple levels of employees in decision-making motivated the work force and helped program managers to make the best decisions. Thus, the relative fit led to realization of the agency's objectives. In other words, the alignment between culture and NASA's structure helped the agency to reach its goal of a lunar landing by the end of the decade.

To summarize the chapter, NASA emerged from a conglomerate of pre-existing organizations such as NACA, the ABMA, and groups from the military. And later it expanded its capabilities with new facilities to complete the moon landing task. The prior organizations were research-oriented containing well-developed technical cultures. NASA did not impose a culture on any of these groups from other organizations to create a dominant culture. The building blocks of NASA's culture were formed by the new interrelationships among these prior organizations.

The key characteristics of NASA's culture between 1958 and 1972 were extensive research and testing, hiring exceptional people, in-house capability, hands-on experience, frontier mentality, and seeing risk and failures as productive aspects of space exploration. NASA was able to hire the best

employees in the nation, thus creating a diverse yet focused workforce. With the help of significant financial support from the President and Congress, NASA accomplished the moon landing task in 1969.

The Apollo task was so large and complex that many parts of it needed to be contracted out. Contracting required development of project management skills. NASA brought in Air Force managers to key positions in program management. To maintain its high internal productivity, the agency preserved core activities such as in-house capability. The controlling and monitoring of contract work was clearly obtained though in-house capability. NASA's technical and research culture, challenges of tasks, competitive salaries, flexible working arrangements with industry and universities, the country's Cold War atmosphere, and the employee selection examination were crucial reasons for the agency's exceptional work force.

Presidential and Congressional support affected NASA culture positively in the first period. With the remarkable financial support, the field centers of the agency just focused on the challenging lunar landing goal. They did not have to compete among themselves to justify their existence at the expense of organizational performance. In addition, the agency being well-funded did not worry about the constraints resource. This kept NASA away from the politics and bureaucracy involved in getting funds.

NASA could be able to have many instruments to better align its culture and people. The instruments were the ability to offer challenging and motivating tasks, pay competitive salary, select best-fitting employees with a unique exam, and allow them easy movement in and out of the agency. The technical and scientific culture ingredients inherited from prior organizations prospered, flourished, and became more distinct with the effective using of these instruments. In the end, the new space agency created a competitive workforce committed to the moon-landing task.

Finally, improvement and success in space exploration completely depend on innovation since the task would be the first of its type. The knowledge, experience and technology were limited and needed to be developed. The inherited technical and scientific culture could perform better in the structure in which its expertise is valued. The space agency had a decentralized adhocracy structure which its distinct characteristics were technical expertise, innovation, fast-decision making, autonomy and flexibility. On top of this, the agency changed its structure whenever the task required it to do so. For example, the agency centrally structured itself for the Apollo task. This restructuring by eliminating the number of levels of structure allowed the agency to respond quickly to the moon landing requirements.

In the next chapter, the cultural analysis of NASA and its alignment with the other system components will be discussed during the second period of NASA (1996–2004). This period culminates with the Columbia accident. Also, whether the culture itself or its degree of alignment with other components explains the causes of the accident will be assessed.

V. NASA CULTURE: ALIGNMENT WITH TASK, PEOPLE, RESOURCES AND STRUCTURE, 1996 TO 2004

This chapter is comprised of two parts: First, we examine the culture of NASA during the period (1996—2004), then the alignment of NASA's culture during this period with its task, people, resources, and structure. In this chapter, the Roger Commission Report and the Columbia Accident Investigation Board (CAIB) are primary sources for analyzing NASA's culture.

We intentionally defined four cultural factors that will help to analyze the NASA culture during this period. These cultural factors—"prove to fail/negative" culture, normalization of deviations and risk, insufficient communication (good news culture), and decreased flexibility (bureaucratic) culture—clearly contributed to the Challenger and Columbia accidents (The Rogers Commission Report, 1986 ; CAIB, 2003). In addition, it is apparent that these four cultural factors reflect a negative change in NASA's culture. Although the scope of our project does not cover the 1972–1996 period, we will refer to that period, particularly factors impacting the Challenger accident, to better describe NASA culture between 1996–2004. We need to refer to the 1972–1996 period because many reports such as the Rogers Commission, the CAIB and academic studies suggest that the same or similar cultural issues were prevalent in the space agency during both accidents. At the end of this chapter, the (mis)alignment between the culture and system components are analyzed to explain how they contributed to the Columbia accident by creating structural and communication gaps resulting in failed performance.

A. NASA CULTURE: (1996–2004)

After the "moon-landing period," Congress began to decrease NASA's annual budget because of the competing priorities of the Vietnam War and the nation's deteriorating socio-economic conditions. NASA embodied the nation's scientific and technological expertise. The Soviet space threat was perceived to diminish alongside diminished American political and societal support of manned

space exploration. Furthermore, the end of the Cold War, symbolized by the tearing down of the Berlin Wall, made dominating space for military purposes a low priority.

To justify its existence and to persuade the nation and Congress to continue to support the space program, NASA developed diversified goals in the mid-1970s. These new goals included a space shuttle program, building an International Space Center (ISS), and the creation of the Hubble telescope. The new space shuttle was designed as a reusable vehicle to prove that NASA could be cost-effective in future space exploration. The space agency also increased the number of flights per year and planned tight launch schedules to demonstrate productivity at minimal cost. In addition, NASA sought to increase the public's interest in space by sending a teacher on a space shuttle mission (the ill-fated Challenger flight) symbolizing how practically every American could benefit from space exploration. Also, to distribute the cost of space exploration to more countries, including Russia, NASA collaborated with other nations by starting development of the International Space Station.

The Rogers Commission and CAIB both placed significant blame for the Challenger and Columbia accidents on the culture that existed at NASA. This culture was influenced by a silent safety program, budgetary constraints, flight schedule pressures, and normalization of deviance and risk. The CAIB report suggested, "By the eve of the Columbia accident, institutional practices that were in effect at the time of the Challenger accident—such as inadequate concern over deviations from expected performance, a silent safety program, and schedule pressure—had returned to NASA" (CAIB, 2003, p. 101).

NASA began to outsource larger portions of projects, than it did during the Apollo project. Instead of concentrating on improving the safety and managerial factors that could negatively affect the space program's performance as recommended by various commissions, NASA tried to do more with less, developing a culture of doing things "faster, better, cheaper."

Now that we have outlined the environment in which NASA operated in during the second period, we focus our attention on the four cultural factors we conclude contributed to the Columbia disaster. We provide specific examples to support our claim that these factors negatively impacted the organization's performance. Additionally, we assess the degree of alignment between culture and the system components during this period.

1. "Proving a Negative" Culture

Although NASA believed that it had a safety program that was active, risk-averse, and empowered to stop any operations if an employee felt there was a problem that compromised flight safety, unfortunately, the CAIB (2003) found no evidence of the safety office operating independently. This fact undermined the belief that NASA had a dedicated safety culture for safe operations in space. NASA's safety culture "has become reactive, complacent, and dominated by unjustified optimism. Overtime, slowly and unintentionally, independent checks and balances intended to increase safety have been eroded in favor of detailed processes that produce massive amounts of data and unwarranted consensus, but little effective communication" (CAIB, 2003, p. 180).

This lack of independence within the safety office was a recurring theme at NASA. At least four more reports outside of the Rogers Commission and CAIB aimed at analyzing NASA mentioned the safety center issue. The CAIB report insisted: "The Shuttle Independent Assessment Team and NASA Integrated Action Team findings mirror those presented by the Rogers Commission. The same communication problems persisted in the Space Shuttle Program at the time of the Columbia accident (CAIB, 2003 p. 179)." A US Senator from South Carolina, Ernest "Fritz" Hollings, stated at a Senate Commerce Committee hearing on the results of the CAIB's report on the Columbia accident, "There's no education in the second kick of a mule. I'm hearing the same things I listened to seventeen years ago" (Berger, 2003).

The second aspect of proving a negative culture that existed in NASA was the need for scientists and engineers to prove a project launch was unsafe. The previous culture relied on engineers and scientists to prove that a project launch was safe. This cultural change occurred during both the Challenger and Columbia eras. The Rogers Commission and the CAIB found this to be true with the engineering decisions made to launch both shuttles (CAIB, 2003, p. 177). In his testimony to the Rogers Commission in January of 1987, Roger Boisjoly described a teleconference between Thiokol and NASA as “a meeting where the determination was to launch, and it was up to us to prove beyond a shadow of a doubt that it was not safe to do so. This is in total reverse to what the position is in a preflight conversation” (Presidential Commission, 1986, p. 93). Mr. Boisjoly was Thiokol’s O-ring expert and advised NASA on technical issues regarding the O-ring. Another example of how the “prove it is unsafe culture” exemplified the culture of NASA is the testimony from the former vice-president of engineering at Thiokol, Robert Lund, who also testified to the Rogers Commission that he had no choice but to change his original recommendation to “not launch” because he now had to prove it was unsafe to launch: “We had to prove to them that we weren’t ready, and so we got ourselves in the thought process that we were trying to find some way to prove to them it wouldn’t work, and we were unable to do that. We couldn’t prove absolutely that the motor wouldn’t work” (Presidential Commission, 1986, p. 811). Therefore, NASA’s culture of proving the negative—that a launch was unsafe—which developed prior to the Challenger disaster also characterized NASA culture prior to the Columbia mishap.

A third indication of how NASA culture had changed during the second period was how employees classified shuttle mishaps and maintenance issues. In hind sight, the O-ring incident which the Roger’s Commission labeled as the root physical cause of the Challenger explosion could have been reclassified as an ongoing safety problem requiring a higher level of alert during the flight readiness review process.

The CAIB stated that the breach in the thermal protection system from insulated foam that separated and struck the reinforced carbon panel is considered to be the physical cause of the loss of the Columbia. This Shuttle mission (STS-107) was not the first flight to lose foam from the main fuel tank. Foam loss was again flagged as a problem after STS 112, which was launched three months prior to the disaster and flown by Space Shuttle Atlantis. Two missions prior to the Columbia's final launch foam loss occurred, but this time an Integrated Hazard Report (IHR) was generated due to the relative size and damage caused during this flight. During the Flight Readiness Review for STS-113, a decision was made to launch without first resolving the foam IHR. Justification for the decision was based on past performance of prior shuttles. Foam loss had never before been classified as a flight safety issue, and no orbiter had ever been damaged enough to create belief that flight safety was compromised. Given this historical evidence, it was concluded that the shuttle was "safe to fly with no new concerns and no new risk" (CAIB, 2003, p. 125). The decision to go ahead and launch is consistent with the "silent safety" culture during this time period.

Given the frequency of lost foam striking the orbiter, it would seem that NASA would have been proactive to prevent further foam strikes from occurring. Unfortunately, NASA decided to classify the foam strikes as only a maintenance issue, which downgraded the importance of the problem to a routine difficulty. The CAIB report suggests, "with each successful landing, it appears that NASA engineers and managers increasingly regarded the foam-shedding as inevitable, and as either unlikely to jeopardize safety or simply an acceptable risk. The distinction between foam loss and debris events also appears to have become blurred. NASA and contractor personnel came to view foam strikes not as a safety of flight issue, but rather a simple maintenance, or "turnaround" issue" (CAIB, p. 122). The space shuttle was designed with the assumption that the booster tanks would not experience any shedding of ice or debris such as foam. Interestingly, a Naval Postgraduate School professional report states, "one of the

original requirements for the Space Shuttle System was that there should be no shedding of ice or other debris during pre-launch and flight. As a result of this requirement, the orbiter was allowed to be designed with a fragile thermal protection system, with minimal requirements to withstand any debris strikes" (Gregory, Marcellino, and Moyer, 2006).

In 1983, the first bipod foam loss was discovered on the Challenger. The problem was classified as an anomaly, and it was required to be resolved before the shuttle could be launched again. Due to repairs to the Orbiter's thermal protection system, the anomaly was closed. Unfortunately, the shedding of foam insulation during launch was never addressed. These examples clearly show that NASA developed a culture of downgrading the importance of mishaps and maintenance problems to stay on schedule and not delay shuttle operations.

2. Normalization of Deviation and Risk Acceptance

The safety culture of NASA during the second period was a direct reflection of the normalization of deviation phenomena. The theory of normalizing is one that occurs from correcting a problem that requires minor adjustments be made to ensure the project or product continues to run smoothly. The root cause of the problem never really gets addressed; therefore, the problem always exists until the primary cause is found and fixed. Hence, the numerous O-ring and foam loss problems that plagued shuttle operations persisted because these problems or deviations were "normalized," resulting in the prime causes of these problems not being addressed.

The acceptance and normalization of risk occurred in NASA at the highest levels of management. The CAIB reports that during the Flight Readiness Reviews for STS-41C, the SRB project manager at Marshall Space Flight Center, Lawrence Mulloy, deemed that some O-ring erosion was acceptable because of the redundancy of the SRB O-ring seals (Presidential Commission, 1986, p. 132). There were many examples of O-ring erosion during this time period: in 1984 three of four flights, in 1985 eight of nine flights, and the flight mission

preceding the Challenger all experienced O-ring erosion. Due to a culture that normalized risk, it is not surprising that at Marshall and Thiokol, senior management classified the O-ring erosion as allowable and acceptable (Choo, p. 159). This normalization and acceptance of risk significantly altered NASA safety culture as early as 1982.

The Columbia disaster provides a more recent example of how normalization of risk undermined NASA's safety culture. Prior to Columbia's disintegration over the southwestern United States, the same faulty pattern of classifying anomalous foam strikes as "maintenance" vice "technical" occurred. The CAIB's investigation revealed that NASA managers had come to accept the fuel tank foam loss and subsequent impact on the orbiter as "acceptable." In retrospect, NASA management used historical successes as validation of the likelihood of future mission accomplishment, despite deviations from the system's intended design and functionality (CAIB, 2003, p. 100). Another example of this mode of organizational thinking occurred after the flight of STS-112, when two more flights were scheduled before confirmation was received from the investigation team investigating the foam strike during that mission. This scheduling can be seen as an unwise effort to adhere to a "success-oriented" program or schedule. The CAIB report (2003) states: "It seems that Shuttle managers had become conditioned over time to not regard foam loss or debris as a safety-of-flight concern." These three specific examples outlined in this section provide strong support that the safety culture of NASA was negatively affected by the overwhelming organizational mindset among senior managers to normalize risk, even though NASA scientists, engineers and contractors remained risk averse.

3. Agreement with Managers Communication Culture

The Columbia Accident Investigation Board made some rather interesting discoveries concerning the communication problems that existed during the second period between management and the engineering communities:

“Managers’ tendency to accept opinions that agree with their own dams the flow of effective communications” (CAIB, 2003, p. 169). Managers tended to reject opposing opinions and accept only those similar to their own. Engineers no longer felt they could freely express their opinions without being ridiculed. The CAIB report stated that: “managers did not seem to understand that as leaders they had a corresponding and perhaps greater obligation to create viable routes for the engineering community to express their views and receive information. This barrier to communications not only blocked the flow of information to mangers, it also prevented the down stream flow of information from managers to engineers, leaving Debris Assessment Team members no basis for understanding the reasoning behind Mission Management Team decisions” (CAIB, 2003, p.169). At the time of the Columbia accident, the communication structure of NASA was flawed. The CAIB observed that “program leaders spent at least as much time making sure hierarchical rules and processes were followed as they did trying to establish why anyone would want a picture of the Orbiter” (CAIB, 2003, p. 181). This example shows the lack of an effective communication structure that did not adequately provide the Missions Management Team (MMT) with valuable information, thereby contributing to flawed decision making.

The CAIB report suggests that the use of PowerPoint briefing slides instead of technical papers led to a problematic technical communication at NASA (CAIB, 2003). The overuse of PowerPoint briefings, in place of detailed analysis, made it difficult for meeting attendees to identify what the launch risks were for Columbia (Guthrie and Shayo, 2005). PowerPoint is a useful tool organizations use to “brief” information to a specified group of individuals. Hence, the word “brief” means exactly that; to provide the audience with the information needed in a short, concise, and brief manner. Therefore, the use of PowerPoint slides may not have been the most effective communication tool to use in communicating extremely technical information. Nor was it a good tool for engineers and scientists to use to express dissenting viewpoints to management

whom created a "good news" culture. Additionally, information passed through NASA in other forms such as the extensive use of viewgraphs. In Visual Explanations (1997), Tufte analyzed the Challenger disaster, showing 13 view graphs prepared for management and faxed to NASA. The critique stated the charts were unconvincing and non-explicit in stating the impact of temperature on O-rings (Guthrie and Shayo, 2005). As a result, the use of viewgraphs to simplify information eliminates many details that may be critical to decision making, and can reduce the importance of critical problems. As stated earlier, management was not accustomed to seek out minority opinions in order to better understand the opportunities available and other viewpoints, which could impact decision making. Therefore, the barriers of communication between managers and engineers, and the incorrect use of communication tools led NASA to have an ineffective communication culture during the Columbia era.

4. Decreasing Flexibility

NASA culture also became less flexible for two reasons: the gradual loss of its technical culture and a more bureaucratic structure. NASA's technical culture decreased in power and influence as a result of reduced in-house capabilities and hands-on experience among the workforce, which discouraged engineers and scientists. According to McCurdy, "NASA employees found themselves increasingly distanced from the actual work of space flight, while organizational resistance to bureaucracy diminished. The original culture lost its power to elicit behavior compatible with the dominant cultural norms" (McCurdy, 1993, p. 133). Previously, hands-on experience and in-house capabilities were valued at NASA during the first period. However, increasing amounts of NASA work was contracted out causing hands-on experience and in-house capability to erode. As a result, NASA scientists and engineers were transformed into contract administrators which compromised the agency's technical capability. McCurdy states "no single factor affected NASA's technical culture more than the increased use of contractors" (McCurdy, 1993, p. 134).

The larger NASA grew, the more difficult it became for headquarters to operate as one entity under a primarily adhocracy structure. As discussed earlier in this chapter, NASA started relying more heavily on a bureaucratic structure to manage its diversified portfolio of projects. As a result, "The agency may lose that flexibility it enjoyed during its formative years. It may become more bureaucratic, and its managers may grow more conservative or averse to risk" (McCurdy, 1993, p. 99). NASA continued to show signs of a transformed organizational structure with characteristics such as limited horizontal decentralization, often typical of large, mature organizations. The new change conflicted with how the organization had always been structured and it was difficult for the workforce to endure. The workforce also began aging and the "new blood" which previously had consistently entered the organization annually slowed. McCurdy exclaims, "The number of young people entering the workforce declined. Engineers and scientists, the core professional group within NASA, advanced in years. As an example, the average age of scientists and engineers increase by four percent between 1966—1990; and the percentage of scientists and engineers 25—34 years of age declined by six percent during the same time frame" (McCurdy table, 1993, p. 105). This change in the make-up of the workforce contributed to the decline in flexibility of the organization. McCurdy further submits:

> Social scientists have speculated about the cumulative effect of changes such as these on the machinery of public administration. Four effects have special importance: the loss of flexibility that comes with age, the tendency of agencies to grow more bureaucratic with time, the likelihood that their executives will become risk-averse as they and their agencies age, and the inclination of agencies struggling to survive to alter their methods of operation (p. 106).

Therefore, the breakdown in safety culture, normalization of deviance, an "agreement with management" communication norm, and declining flexibility defined an organizational culture during the Columbia period significantly

different from NASA's culture during the Apollo project period. The next segment examines the extent to which task, people, resources, and structure were aligned with this changed culture during the second period.

B. NASA CULTURE: ALIGNMENT WITH TASK, PEOPLE, RESOURCES, AND STRUCTURE (1996—2004)

1. Task

In the first period (1958—1972), we concluded that NASA's overarching task, although visionary induced, was specific and complex, with a definitive end-state. When President Kennedy vowed to land a man on the moon and bring him back safely, he both challenged and empowered NASA to complete an extremely challenging mission.

In the Columbia period, NASA was dealing with two dependent tasks: the ISS and the Space Shuttle Program. Although the agency declared the space shuttle in the early 1980's as "operational" versus "developmental/experimental," various problems such as foam strikes had been occurring in the shuttle flights. In other words, the entire history of the shuttle program may thus be viewed as the "incubation period" where failures persist or accumulate for the Columbia disaster. Additionally, design alterations and unpredictable flight conditions led to anomalies on many flight shuttle missions. In sum, the space shuttle was not meeting the demands of operational capability which increased the risks of the Shuttle flights. The CAIB emphasized the risk of space flight as: "operation of the space shuttle, and all human space flight, is a developmental activity with high inherent risks" (CAIB, 2003, p. 9).

The CAIB report stated that, with the International Space Center assembly more than half-complete, the station and the shuttle programs had become irreversibly linked. Such dependency between the two programs served to reduce the value of STS-107's Flight Readiness Review because a delay in STS-107's launch would cause serious delays in the completion of the Space station.

The CAIB explained that: “Any problems with or perturbations to the planned schedule of one program reverberated through both programs” (2003, p. 117).

The fiscal year 2002 budget announced that the US part of the ISS would be considered complete with the installation on the ISS of “Node 2,” which would allow Europe and Japan to connect their laboratory modules to the station. Node 2 was to be launched in 2004 (CAIB, 2003). Five shuttle launches were planned until the launch of Node 2. Any technical problem that delays one launch would directly affect the Node 2 launch (CAIB, 2003). In 2002, STS-112, the fourth flight before Columbia, flew and lost foam. The review board assigned an action to the loss but the due date for the action was delayed due to the next flight, STS-113. The CAIB stated that: “The pressing need to launch STS-113, to retrieve the International Space Center Expedition 5 crew… and to continue to countdown to Node 2 were surely in the back of managers’ minds during these reviews” (2003, p. 138). The STS-107, Columbia, Mission Management Team chair, Linda Ham, joined the discussion of the foam of STST-112, and also joined the Flight Readiness Review for STS-113. She was also launch integration manager of the STS-114 mission. After the foam loss of Columbia shuttle, most of her inquiries about the strike were not about what action to take for Columbia but how to understand the implications for STS-114. The space shuttle program concerns about the Columbia foam strike were not about the threat it might pose to STS-107 but the threat it might pose to the schedule (CAIB, 2003, p. 139).

Consequently, the interdependency of the Space Station program with the Shuttle program increased overall complexity, causing serious gaps between management, engineer and safety mindsets. The shuttle program promised to frequent access to space with a tight flight schedule. However, linkages of tasks (the Shuttle and the ISS) created pressures and trade-offs concerning flight schedules. Agreement with Shuttle program managers dominated discussions, creating a norm of top-down, yet fractured communications. The safety culture eroded over time and a “prove it is unsafe” culture fit with the new direction of staying on schedule—apparently at all costs. Flight problems were increasingly

treated as normal based on previous flights with foam problems. The bureaucratic culture of NASA was doing what machine bureaucracies often do—maintain stability and predictability, which does not include “rocking the boat.”

2. People

During this second period, NASA lost its “research-oriented” technical culture which encouraged the agency to hire highly skilled personnel in the first period. Additionally, a substantial occupational cultural conflict emerged between managers and engineers, which included substantial and enduring differences in values. As clarified in Chapter II, the integration and attainment of a strong, aligned organizational culture is paramount for successful overall performance. On top of that, there was a considerable work force reduction in the second period, obviously introducing the added pressure of possible job loss.

Beginning in the 1970s, NASA became a much more bureaucratic organization that had moved away from the “research-oriented” culture of Apollo, and organizational power shifted from the core of researchers and engineers to the upper levels of management. After the Challenger disaster, the change appeared even more dramatic, and the CAIB reported this: “The Space Shuttle program had been built on compromises hammered out by the White House and NASA headquarters. As a result, NASA was transformed from a research and development agency to a more of a business, with schedules, production pressures, deadlines, and cost efficiency goals elevated to the level of technical innovation and safety goals” (CAIB, 2003, p. 199). The agency’s Apollo era research and development cultural respect for technical expertise among its working engineers was overridden in the space shuttle era by “bureaucratic accountability.” The procedures, the chain of command and hierarchy were the new norms that engineers and scientists had to obey during their projects. In sum, NASA’s culture traded its “research-oriented” attractiveness for command, control and accountability to a pluralism of stakeholders.

The Columbia period exemplifies the almost insoluble conflict between engineers and managers. The managerial mindset was to maintain tight flight schedules, decrease costs per flight, focus on the funding, and assure the smooth continuation of the program. The engineering mindset was to always lean in the direction of safety through testing and retesting. The CAIB succinctly described this issue in terms of work being scheduled on holidays, a third shift of workers being hired and trained, future crew rotations drifting beyond 180 days, and some tests previously deemed 'requirements' being skipped or deferred.

Program managers estimated that Node 2 launch would be one to two months late. "They were slowly accepting additional risk in trying to meet a schedule that probably could not be met" (2003, p. 138). Clearly, managers overruling engineers and scientists in the divided tasking of the space agency confused and frustrated the previously dominant scientific culture. Another example showing occupational cultural conflict occurred after the moon-landing. Morton Thiokol's general manager, Jerald Mason, at the meeting where the launch of Challenger was unanimously approved by four managers who ignored the engineers sitting with them around the table said: "take off your engineering hat and put on your management hat" (Milliken & Starbuck, 1988). NASA dominant mindsets were in conflict, and the occupational cultures were not integrated resulting in disastrous decisions. The conflicts between a safety-first, and a schedule-first mindset contributed to the Columbia disaster.

Finally, there was a sizable reduction in the NASA workforce throughout 1990s. Between 1993 and 2003, 6,000 jobs were cut causing a 25 percent workforce reduction (CAIB, 2003, p. 110), which also adversely affected employees and the Shuttle program. For the Shuttle program alone, headcount was reduced from 120 in 1993 to 12 in 2003 (CAIB, 2003, p. 110). When paired with the "faster, better, cheaper" motto of the 1990s, personnel cuts dramatically decreased numbers of safety personnel, refocusing the surviving personnel around business efficiency principles (CAIB, 2003, p. 199).

To summarize, the emerging and dominant hierarchical bureaucratic culture did not fit the original scientific and safety orientation of the agency, including loss of appeal for attracting new engineers and scientists. Also, workforce reductions exacerbated the occupational cultural divide by ensuring surviving technical personnel understood their diminished roles.

3. Resources

The resource component in the second period was slightly changed in the Columbia period. Time for example, became more critical due to the importance of maintaining tight flight schedules. This section focuses primarily on capital resources, including added pressures resulting from requirements to operate in an environment of constrained resources. "Pressures" translated into preoccupation with tight budgets, tight flight schedule operations, and a yielding to business and political priorities. NASA management was convinced it needed to generate additional revenues by undertaking new, private sector projects (CAIB, 2003, p. 111). These ill-conceived projects ultimately failed and used up resources, while the international space center fell behind schedule and went over budget (CAIB, 2003, pp. 107-110). The Shuttle program was weakened by a lack of investment in safety upgrades and infrastructure (CAIB, 2003, pp. 111, 114-115). Again, new priorities mixed with declining resources negatively affected the culture.

By 2001, a succession of failed investments and inadequate cost-control efforts had tarnished NASA's credibility, and Congress withdrew their long-term commitment to financing the ISS program. Instead, Congress put the agency on probation, requesting that NASA refocus its resources on the ISS program and simultaneously reduce program costs (CAIB, 2003, p. 117). They also requested that completion of a critical part of the program (Node 2) be reached within the next two years (CAIB, 2003, p. 116), the implication being that if NASA failed at

launching Node 2 within the allocated budget, the ISS program would be eliminated, and NASA's future ability to get funded would be substantially impaired (CAIB, 2003, pp. 116-117).

After a decade of lay-offs, misdirected research efforts, frequent starts and stops on projects, and underinvestment in infrastructure and safety issues, the organization lost its temporal resilience.

NASA continued to be dependent on contracting-out with industry leaders in order to fulfill its missions under limited resources. Contracts were for numerous parts of the space and shuttle programs such as engines, communication systems, and satellites. If vital parts were not provided, the space and shuttle programs would not survive. However, contractors' work appeared to fall under the required and expected operational and safety intentions. For example, from the beginning, Morton Thiokol provided a faulty O-ring design.

NASA's core competencies were in design plans and operations of the space and shuttle programs; therefore, it appeared beneficial to contract out production work.

NASA began experiencing "constrained resources" during the early 1970s, no doubt an unfamiliar state from the 1960's when the programs were fully funded and the nation supported the mission. Figure 8 displays NASA's budget from 1962–2002. During the 40 years span, NASA reached its budget peak in 1966 and reached its bottom in 1976. NASA continued to be funded at a rate below historical averages. Between 1993 and 2002, the governments discretionary spending grew in purchasing power by more than 25 percent, defense spending by 15 percent, and non-defense spending by 40 percent. NASA's budget, in comparison, showed little change, going from $14.31 billion in Fiscal Year 1993 to a low of $13.6 billion in Fiscal Year 2000, and increasing to $14.87 billion in Fiscal Year 2002. This represented a loss of 13 percent in purchasing power over the decade.

Faced with this budget situation, NASA had the choice of either eliminating major programs or achieving greater efficiencies while maintaining its existing agenda. Agency leaders chose to attempt the latter. They continued to develop the Space Station and continued Shuttle-based missions. In 1994, they took on the responsibility for developing an advanced technology launch vehicle in partnership with the private sector, while attempting to be more efficient, hence the 1990s branding of “faster, better, cheaper.”

A relatively flat NASA budget appeared to particularly affect the human space flight enterprise. During the decade before the Columbia accident, NASA rebalanced the share of its budget allocated to human space flight from 48 percent of agency funding in Fiscal Year 1991 to 38 percent in Fiscal Year 1999, with the remainder going mainly to other science and technology efforts. On NASA’s fixed budget, that meant the space shuttle and the international space station were competing for decreasing resources.

NASA has endured an environment of constrained resources since the 1970s. These pressures encouraged management to develop a culture of cost-savings, cost-efficiency, and flight schedule order.

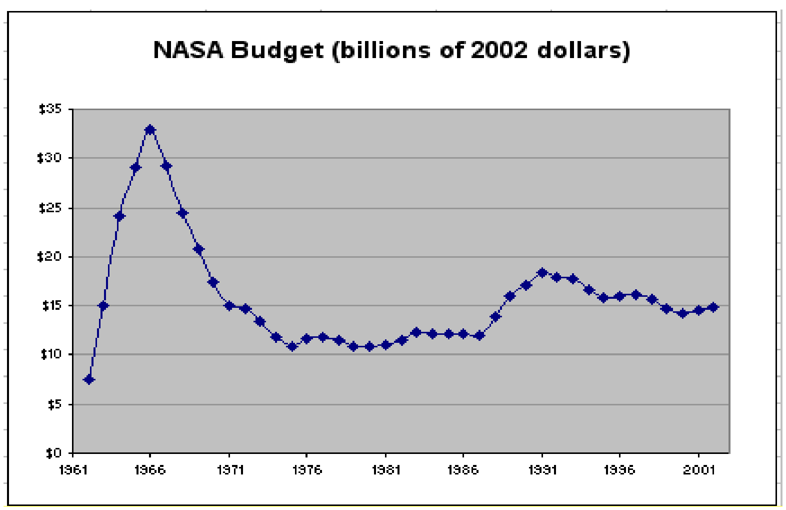

Figure 8. NASA’s Budget (1958—2001) (From: National Association of Science Writers, www.nasw.org, accessed December 2007)

To summarize, constrained (flat) resources, time and political pressures and dependence on contracting were serious precursors contributing to managements' behaviors crowding-out safety concerns, including the engineering personnel voicing those concerns. NASA sought and emphasized cost saving initiatives attempting to maximize allocated funds. In sum, misfits of key factors continued to abound during the Columbia period.

4. Structure

Several authors (McCurdy, 1993; Minztberg, 1979) suggest that organizational structure changes as the organization ages and grows. In other words, it is difficult to maintain the same organizational structure for extended time periods.

When the Columbia accident happened, 45 years had passed since the establishment of NASA. During this time period, the agency's space shuttle program promising frequent access to space and construction of the ISS in an environment of constrained resources contributed to a structural shift from adhocracy to machine bureaucracy. So structure, goals and cultural mindsets became malaligned.

The bureaucratic NASA structure contributed to the Columbia accident (CAIB, 2003). During the Columbia period, NASA partially made the structural changes that the Rogers Commission recommended, e.g., centralizing operations and safety controls. Although the agency initiated the recommended Headquarters Office of Safety, Reliability and Quality Assurance (Safety and Mission Assurance Office), it did not provide direct authority over all safety operations as recommended; rather, each center had its own safety group reporting to the center director (CAIB, 2003, p. 101).

According to the CAIB: "NASA did not adequately prepare for the consequences of adding organizational structure and process complexity in the transition to the Space Flight Operations Contract. The agency's lack of a

centralized clearinghouse for integration and safety further hindered safe operations" (2003, p. 187). The Safety Office was not structurally linked to shuttle program management during the Columbia accident. The CAIB further explained that: "Given that the entire Safety and Mission organization depends on the shuttle program for resources and simultaneously lacks the independent ability to conduct detailed analysis, cost and schedule pressures can easily and unintentionally influence safety deliberations. Structure and process places Shuttle safety programs in the unenviable position of having to choose between rubber-stamping engineering analysis, technical efforts, and Shuttle program decisions, or trying to carry the day during a committee meeting in which the other side almost always has more information and analytic capability (p. 187), Figure 1 shows the Safety Office within NASA at the time of Columbia accident.

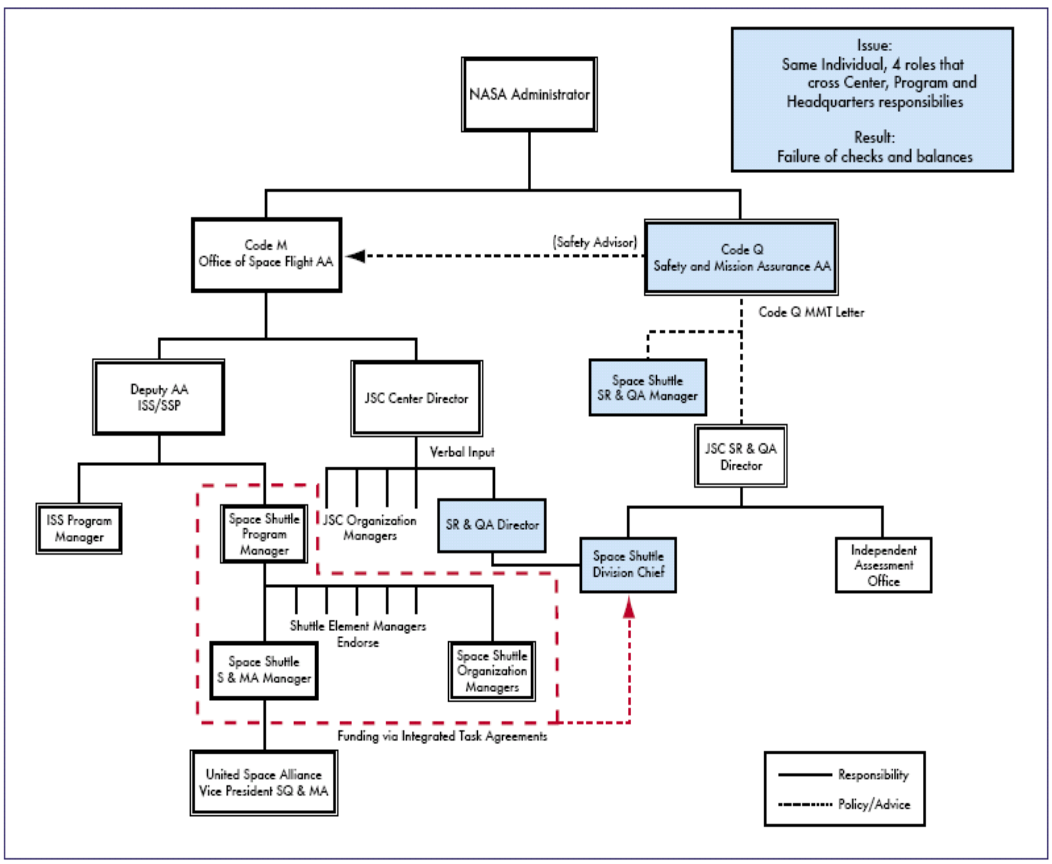

Figure 9. Safety Office within NASA Organization at Time of the Columbia Accident (From: Columbia Accident Investigation Board, (p. 185))

As seen in Figure 9, management did not empower the Safety Office, including being reliant on the funding from the shuttle program they supported, instead of being independent. If the budget of the program was reduced, the safety group was likely to take as much of a cut as any other part of the program. Also, if the number of flights were reduced, the funds for flights would also be reduced or the program would be cancelled. This was a significant risk that not only affected the space shuttle program, but the International Space Station would also suffer since the shuttle program had been used to transport parts of the ISS.

The structural (financial) dependency of the safety office, competing priorities, and conflicting interests' of safety personnel (survival) eroded overall safety pushing the once dominant value to the sidelines. No single person was responsible for Shuttle mission safety, and the office did not provide an integrated organizational process for ensuring safety remained paramount.

The CAIB (2003) called for the agency to make structural changes to improve the problematic safety structure by creating a centralized safety oversight. A new shuttle Safety Panel would report to the shuttle program manager. Also, an independent Office of Safety, Reliability and Quality Assurance would be established, headed by an associate NASA administrator, with independent funding and direct authority over all safety bodies throughout the agency. It would report to the NASA administrator, rather than program manager, thus keeping safety structurally separate from the part of NASA responsible for budget and operations efficiency.

As a conclusion, the structural dependency of the Safety Office created financial dependency degrading the ability to intervene based on safety concerns. NASA structure therefore reinforced its “silent safety” culture, its normalization of deviances and risk, and its protocol of bowing to management when addressing safety concerns, i.e., a communications gap or misfit between managerial and engineering cultures. Possibly, although difficult to provide clear

evidence, structural dependency might also lead to “cultural dependence” in terms of the Safety Office adopting the same mindset of program managers over time, thereby forfeiting their primary function.

NASA culture changed substantially into a “prove it is unsafe” mentality, normalization of deviance and risk, decreased flexibility, and ineffective communication leading to the misalignment of system components ultimately degrading performance. NASA developed diversified goals not supported or aligned with its earlier culture. Space flights in the first and second periods required overarching and comprehensive safety linkages, but during the second period values shifted to a “prove it is unsafe” launch mindset. Normalization or rationalization of operational deviations widened the gap. NASA continued to fly the shuttle even with the known problems of O-ring blow-by and foam breakage from the launch vehicle.

Due to increasingly tight and decreasing financial resources, NASA adopted an extremely tight flight schedule to demonstrate its efficiency and cost reductions per flight to policy makers. Unfortunately, compressed schedules exacerbated safety problems. With a limited budget, the agency contracted out the critical parts of the shuttle project including design and testing. Contractors were told to perform thorough testing of shuttle components at their manufacturing plants and to deliver components to the launch site ready to fly (McCurdy, 1993). As a result, the agency lost portions of its internal capability.

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VI. CONCLUSION

This research examined the interaction of external and internal organizational variables affecting cultural changes occurring in NASA during two key time-periods, 1958–1972 and 1996–2004. In the first timeframe, 1958–1972, cultural characteristics are described which may have positively contributed to the successful landing and safe return of a man on the moon. During the second timeframe, 1996–2004, culturally relevant factors are described and analyzed that could have contributed to the Columbia shuttle disaster.

This work used a modified version of McCaskey's open systems model to determine the degree of alignment between NASA culture and important system components—task, people, resources, and structure—during these two periods. Finally, this research determined if there was a relationship between NASA's organizational performance and the degree of alignment between NASA's culture and its system components.

The conclusion of the project indicates that while the key variables of NASA's culture were well aligned with the system components—task, people, resources, and structure—and supported the task performance in the first period (1958–1972), a lack of congruence between the system components of the space agency and its culture caused a performance gap that led to the Columbia disaster in the second period (1996–2004).

Organizational culture can be described as patterns of shared beliefs, values and assumptions over time, which guide members of the organization as to the correct way to perceive, think about, and solve organizational problems. These patterns develop over time so that beliefs and values become shared and the behaviors that result from them are considered normal and thus accepted. Culture is transmitted and taught to new members through a process of socialization, which is a valuable managerial tool for creating a sense of identity,

promoting organizational commitment, enhancing social system stability, and serving as a sense-making device that can guide and shape behavior (O'Reilly & Tushman, 1997; Simircich, 1983). Additionally, culture affects the decision-making process by framing the interpretations of the members of the organizations. The employees attach importance to their priorities according to their assumptions and values.

Culture can be the most abstract aspect of an organization. The most intriguing aspect of culture is that it points to phenomena that are below the organizational surface, that are powerful in their impact but invisible and to a considerable degree unconscious. Culture is to a group or organization what personality or character is to an individual. Yet, just as the personality and character guide and constraint an individual behavior, so does culture guide and constrain the behavior of a group through the shared norms, values and assumptions held by the group. In this sense, culture is a valuable tool of social control in organizations.

Organizational culture is one of the key variables affecting organizational performance. Ouchi and Wilkins (1983) have clearly pointed out that "organizational performance cannot be adequately nor accurately understood without a comprehension of the culture of the organization" (p. 469). In addition, many other researchers (Barney, 1991; Gordon, 1985; Hesket & Kotter, 1992; Peters & Waterman, 1982; Schein, 1996) have supported the argument that cultural "strength" or certain kinds of cultures correlate with company performance. However, strong cultures that do not fit a company's environment can lead intelligent people to behave destructively, undermining an organization's ability to survive and prosper (Hesket &, Kotter, 1992). In other words, whether or not a culture is "good" or "bad," "functionality effective" or not, depends not on the culture alone, but on the alignment of culture with important organizational components (O'Reilly & Tushman, 1997; Schein, 2004).

This project's analysis demonstrated the importance of alignment between NASA's culture and its key organizational components. Furthermore, the degree

of alignment correlated with NASA's performance. Specifically, the space agency's technical and research culture was closely aligned with key organizational components—task, people, resources and structure. This alignment enabled NASA to complete successfully one of the most challenging missions given to an agency: landing a man on the moon before the end of the 1960s. Figure 10 outlines NASA culture between 1958–1972 and its alignment with key system components using as a framework a modified version of McCaskey's organizational systems model.

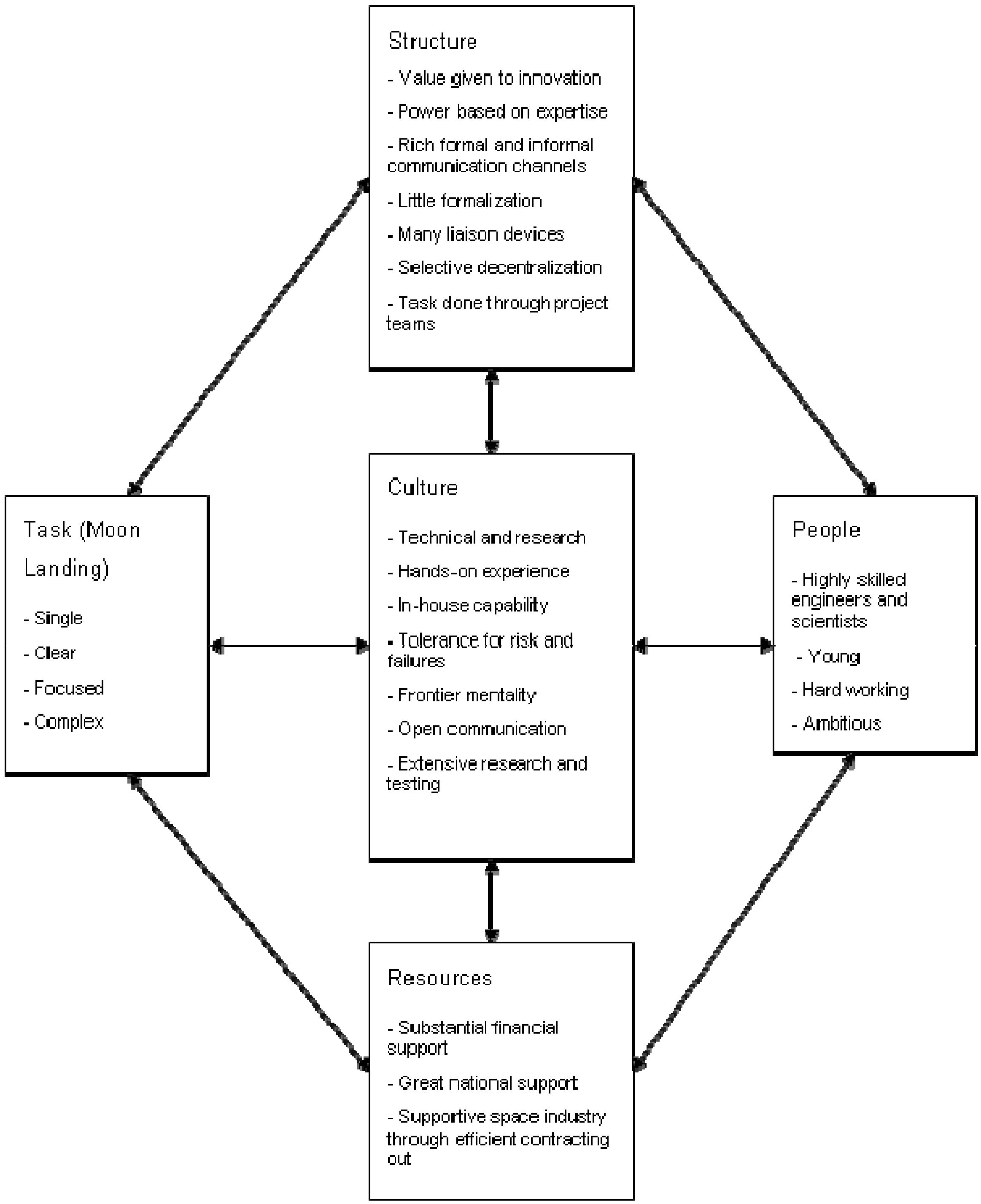

Figure 10. The fit of NASA culture and organizational components (1958—1972) (After: McCaskey (1974); Nadler & Tushman, (1997))

As easily seen from Figure 10, NASA had a clearly defined moon-landing task which kept the people of the agency alert and motivated. If the agency put a man on the moon before 1970, the technological and scientific superiority of the US would be established against Russia. NASA's knowledge about manned space exploration was limited at the beginning. As a result, the agency developed two intermediate projects: Mercury, Gemini. NASA incrementally increased the space exploration knowledge with these two projects. In other words, it developed further operational capability in space and became experienced about the problems of living and working in space. These two projects were necessary to develop the scientific and engineering knowledge required to complete Project Apollo successfully.

The Mercury, Gemini and particularly the Apollo project required NASA to contract out much of its because the agency did not have the in-house capability to do all the work in-house. However, NASA effectively controlled and monitored the contractors by doing the most important parts of the projects such as design in-house.

NASA's culture facilitated the agency's task performance. In-house technical capability, research and testing, hands-on experience, seeing risk and failures as part of the space exploration, frontier mentality and hiring exceptional people were the distinct cultural factors during the first period of the space agency (1958—1972). In short, it had a technical and research culture. With its technical and scientific in-house expertise, NASA completed the critical parts of the projects with its own people and successfully managed the contractors, insuring that design, cost and schedule met the moon-landing program requirements. This was very important since the moon-landing task had a time constraint. In-house capability also enabled the agency's employees to acquire hands-on experience. Regardless of the cost incurred by testing, learning, accumulation of knowledge and safety were highly valued in NASA culture. Risks

involved in space flights were recognized, but no flights were allowed before eliminating all recognizable problems. Extensive research and testing were done to accumulate knowledge that ensured safety.

In addition, people were allowed to make mistakes and learn from those mistakes. The engineers and scientists were given flexibility and autonomy in their projects to try out new ideas, to innovate and to sharpen their skills. The decisions were made based on the technical merits and people of the agency voiced their concern in the decision-making process. The culture energized its people to accomplish the task.

One of the reasons behind the successful moon landing was the exceptional work force of NASA which was well-aligned with the task and the substantial financial support. The agency's internal organizational environment was very attractive because of NASA's technical and research culture, challenging tasks, competitive salaries, and flexible working arrangements with industry and universities for skilled engineers and scientists. Additionally, the outside environment of the agency was supportive due to the country's Cold War atmosphere. Highly skilled people who wanted to do their duty for their country viewed NASA as an ideal place to work. The agency was able to select people with the skills required to complete its demanding work and to fit its culture through a rigorous employee selection examination.. Finally, NASA was able to attract and retain a young, competent, ambitious, committed and motivated workforce who met rigorous task demands. The technical and scientific culture of the organization prospered, flourished, and became more distinct due to its ability to hire people with the unique blend of skills and motivation that NASA required to meet the challenges of Project Apollo.

NASA had the support of the president, congress and nation which affected NASA culture positively. With its significant financial support, the agency did not worry about the funds and focused on the challenging lunar landing goal. This kept NASA away from the politics and bureaucracy involved in getting funds,

allowing the agency to protect its research-oriented cultural environment. The field centers did not have to compete among themselves to justify their existence at the expense of organizational performance.

Another organizational component which was also well-aligned was the structure of the agency. Improvement and success in space exploration completely depended on innovation since the moon-landing task would be the first of its type. The knowledge, experience and technology were limited and needed to be developed. The size and complexity of the projects demanded project teams which have various technical skills and expertise. The nature of the tasks and the work needs of the people completing the work indicated that NASA required an adhocracy structure. This structure places high value on technical expertise, innovation, fast-decision making, autonomy and flexibility. Also, NASA's adhocracy structure allowed the agency to change its internal shape frequently. Because of this ability to reshape itself to meet project needs, the agency centrally structured itself for the Apollo task. This restructuring eliminated the number of vertical layers of structure and allowed field centers to cooperate, enabling the centers to respond quickly to moon-landing requirements.

The alignment of NASA's culture with its task, people, resources, and structure in the first period (1958–1972) culminated with the moon landing. NASA's culture during this period and the close alignment or fit of the culture, tasks, people, resources, and structure were instrumental in the successful completion of this challenging project.

When contextual factors change, culture also changes (Heck & Marcoulides, 1993; Louis, 1985; Schein, 2004; Uttal 1983). NASA's technical and research culture transformed into bureaucratic culture. After the agency's specific moon landing task, new tasks were diversified. Resources were substantially limited to support the tasks. A flexible adhocracy structure was replaced with a bureaucratic structure. These changes in organizational components caused misalignments between culture and components which affected NASA's performance. The agency's management was not able to successfully manage

these changes and realign system components with each other and culture. Figure 11 displays the culture of NASA and its alignment with the system components in the second period (1996–2004).

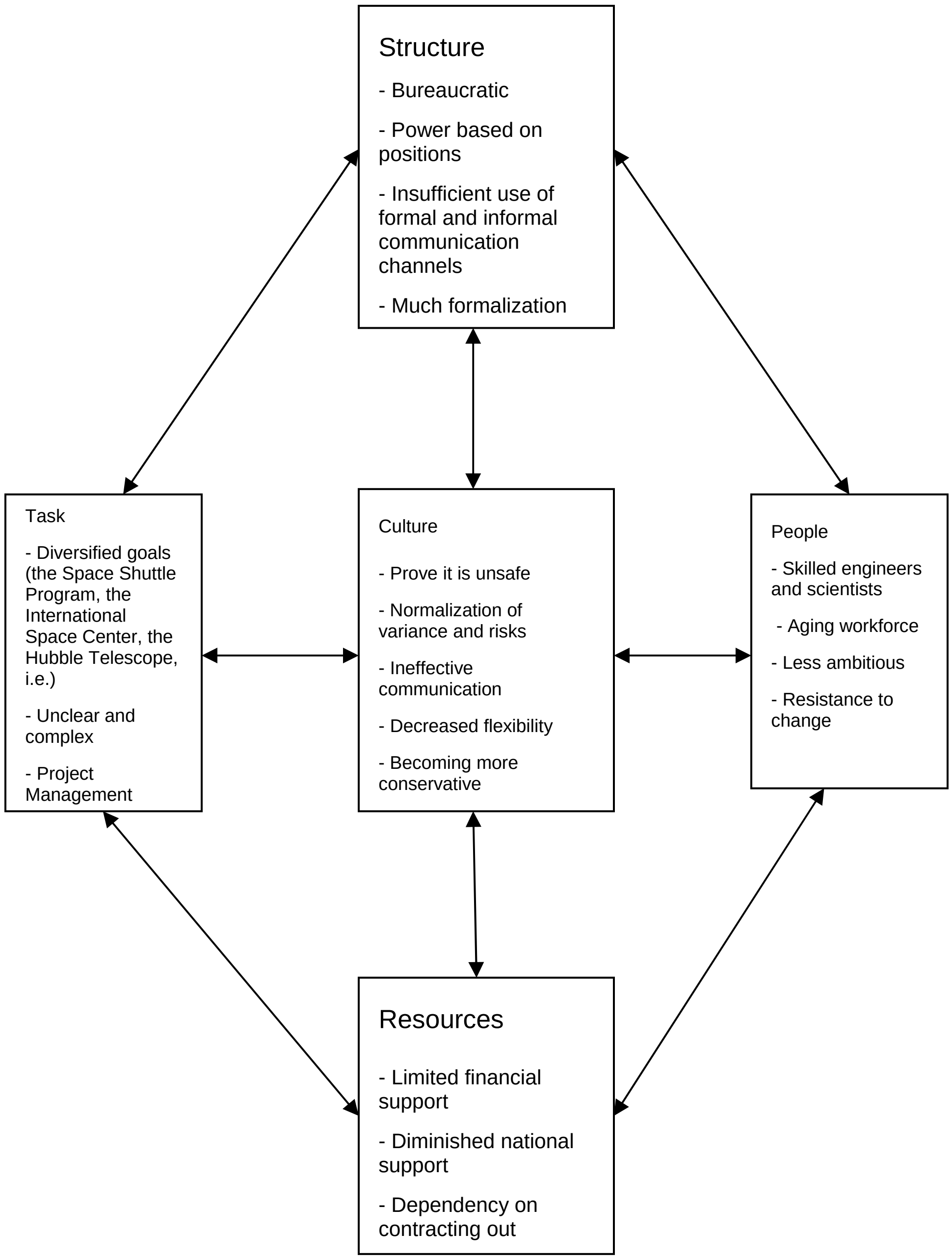

Figure 11. The fit of NASA culture and organizational components (1996—2004) (After: McCaskey (1974); Nadler & Tushman (1997))

Figure 11 clearly displays the system components and its attributes of our model during the Columbia period. One of the factors that contributed to the change in task component was that after NASA landed the first man on the moon, the concern that Russia might use space as a nuclear platform diminished. As a result, the agency's mission became unclear, resulting in a significant diversification of tasks that remained very complex and still required new scientific and engineering knowledge. In this atmosphere, NASA had to justify its existence; furthermore, in order to get funds it was required to develop diversified goals such as Skylab, the space shuttle program, the Hubble Telescope, and an orbiting international Space Center.

The US's deteriorating economic conditions and Vietnam War were pressing issues and Congress began to cut back the agency's funds. In an effort to further justify its existence, NASA designed the space shuttle as a reusable vehicle to assure Congress that space exploration would be cost-effective. Additionally, the work of the professionals in NASA, who formerly conducted engineering and scientific research, became less technical and more administrative. NASA required project management skills and abilities because NASA increasingly relied on contractors to carry out its diversified portfolio of projects. In fact, NASA not only was contracting out production work but also design plans. These changes created a rift between managers and engineers that affected NASA's safety and technical culture.

As NASA matured, so did its workforce. The aging workforce became less ambitious and more resistant to change. No longer was NASA an organization with a frontier mentality, but rather an organization fighting for survival. In order to survive, the engineers and scientists had to embrace the change in tasks of being project managers. By contracting out more, NASA was able to reduce costs and share liability with industry leaders. Unfortunately, as indicated earlier, the safety culture of NASA was compromised because no

longer were the engineers and scientists going through three iterations of safety testing as previously done. The contractors were now responsible for the testing and retesting of products.

Another way that this changed culture affected the people component was the “prove it is unsafe” belief. Managers required engineers to prove a part or product was unsafe before a decision would be made to stop a shuttle launch. This new way of thinking was in conflict with the former culture of “prove it is safe” to launch. As a result, the safety culture suffered because engineers were unable to convince management to stop what they believed to be risky launches because these engineers still operated under assumptions that they only needed to disprove that it was safe to launch.

Costs saving initiatives were implemented by management to help supplement shortfalls in the budget as well as further justify NASA’s existence. The diversified goals and resources available to support them were not well aligned. There were not enough funds allocated by Congress to pay for the numerous goals NASA wanted to accomplish, so partnerships and outsourcing became valued. For example, the International Space Station will be paid for by the international community and not just the United States. This was a brilliant attempt for NASA to show cost savings and reduce its liability. However, the space shuttle program was impacted negatively by the constrained resource environment.

In an effort to reduce costs, NASA believed in a continuous flight plan. Management thought was that if NASA could launch more flights, then the overall cost per flight would decrease and result in savings. Unfortunately, the strict flight schedule pressured management to send shuttles to space that may have been less safe. This led to the development of the “prove it is unsafe” culture previously discussed.

Along with this belief, some risks were treated as normal by management which created the normalization of risk phenomena. There were scientists and

engineers who knew of the problems of the space shuttle first-hand but did not voice their concern and did not inform the higher managers due to a culture that normalized deviance and required technical staff to “prove it is unsafe” to launch a shuttle. Therefore, the budget constraints and flight schedule pressures increased the amount of risk managers were willing to accept and at the same time decreased safety awareness.

Finally, the structure of the organization was not aligned with the culture. More specifically, the safety culture was incongruent with how the organization was structured. NASA is a highly technical organization that performs work that is extremely dangerous. Therefore, safety should be the cornerstone of all operations. Unfortunately, the Rogers Commission and Columbia Accident Investigation Board found this not to be true. Both reports recommended that the Safety Office of the agency be independent of the research centers. The Safety Office should report directly and only to the NASA Administrator. The independence of the Safety Office would prevent any internal pressures that may influence results of investigation reports or recommendations to leadership. Therefore, we conclude that the bureaucratic structure and safety culture were in misalignment.

NASA culture made a dynamic shift during Columbia period. There were two common themes that resonated among the cultural variables and system components; these themes were 1.) Pressures from a constrained resource environment and 2.) The lack of a safety culture. These two factors played a significant role in shaping the organizational culture of NASA. The key variables from the change in culture; “prove it is unsafe,” normalization or risk, and declining flexibility greatly influenced the misalignment of culture with task, people, resources, and structure. Therefore, we conclude these misalignments, which created performance gaps in NASA, contributed to the Columbia disaster.

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